Economic Impact of an Infection Control Education Program in a Specialized Preschool Setting

Stacey J. Ackerman, MSE, PhD*; Steven B. Duff, MS‡; Penelope H. Dennehy, MD§; Michael S. Mafilios‡; and Leonard R. Krilov, MD‖

ABSTRACT. ***Objective.*** **To assess the economic impact, from a societal perspective, of a multidimensional infection control education program (ICEP) in a preschool for children with Down syndrome.**

Methods. **Krilov et al implemented a comprehensive ICEP in a specialized preschool setting and reported a significant decrease in medical resource utilization and days absent from school. Clinical and economic data from Krilov et al and other sources were incorporated into a health-state transition (Markov) decision analysis model that estimated annual expected costs for the baseline and intervention years. Procedure and diagnosis codes were assigned to all physician office visits, emergency department visits, hospitalizations, and laboratory and diagnostic tests. Cost estimates then were derived using 1999 national reimbursement schedules and other sources. Productivity losses for parents were estimated using national wage rates. The costs of the ICEP were compared with the reduction in the costs of illness (direct medical costs plus costs associated with lost parental working time). The outcomes measured were mean annual costs of illness per child, total annual ICEP costs, and net annual costs or savings.**

Results. **With a comprehensive ICEP, the mean costs of illness in the baseline year was $1235 per child, of which 68% and 14% were for productivity losses and physician visits, respectively. In the intervention year, the mean costs of illness per child was $615, of which 71% and 20% were for productivity losses and physician visits, respectively. The cost of the preexisting infection control (IC) practices in place at the onset of the study (baseline year) was $716. The comprehensive ICEP cost (intervention year) was $75 627, 92% of which was spent to hire a cleaning service to decontaminate toys 3 times per week. When a secondary analysis was performed to reflect a less intensive ICEP in a nonspecialized preschool setting, the mean costs of illness in the baseline and intervention years were $962 and $614 per child, respectively, representing a total annual cost-of-illness savings of $13 224 for the 38 children who participated in the study by Krilov et al. The annual incremental cost of the less intensive ICEP was $2371; therefore, the estimated net annual savings of the less intensive ICEP in a nonspecialized preschool was $10 853.**

Conclusions. **This study suggests that the reduction in the costs of illness could more than offset the cost of implementing a multidimensional ICEP in a preschool setting.** ***Pediatrics*** **2001;108(6). URL: http://www.pediatrics.org/cgi/content/full/108/6/e102;** ***infectious disease, infection control, preschool, economics.***

From Covance Health Economics and Outcomes Services Inc, *Gaithersburg, Maryland, and ‡San Diego, California; §Division of Pediatric Infectious Diseases, Hasbro Children's Hospital, Brown Medical School, Providence, Rhode Island; and ‖Pediatric Infectious Diseases, Winthrop Pediatric Specialty Center, Winthrop University Hospital, Mineola, New York.

Received for publication Jun 2, 2000; accepted Jul 26, 2001.

Reprint requests to (S.J.A.) Covance Health Economics and Outcomes Services Inc, 9801 Washingtonian Blvd, 9th Floor, Gaithersburg, MD 20878-5355. E-mail: stacey.ackerman@covance.com

ABBREVIATIONS. DCC, day care center; ICEP, infection control education program; IC, infection control; OTC, over-the-counter.

Because of the rise in the number of 2-wage-earner families, roughly 3 million US children younger than 5 years of age now attend facility-based day care centers (DCCs).[1] This trend is likely to continue, given that the Bush Administration's fiscal year 2002 budget proposal includes a dependent care tax credit to defray expenses for working families, as well as other ongoing initiatives such as the Head Start program and the Child Care and Development Block Grant.[2]

It is widely known that children who attend DCCs are at increased risk of respiratory, ear, and gastrointestinal infections[3–13] and that high-risk children, such as those with congenital heart disease or chronic lung disease, can experience substantial morbidity.[14] Haskins[15,16] estimated that the economic burden to our society of this excess illness exceeds $1.4 billion annually (1999 US dollars).

Infection control education programs (ICEPs) have been shown to be effective in reducing infectious pathogens and clinical cases of infectious diseases in DCCs.[17–28] ICEPs are often multidimensional programs that include training, an emphasis on handwashing, compliance monitoring, and disinfecting supplies. To our knowledge, the potential cost savings attributable to ICEPs in the DCC setting have not yet been evaluated.

The objective of this study was to estimate, through computer modeling, the economic impact of a comprehensive ICEP implemented in a specialized preschool setting for children with Down syndrome.[24] Krilov et al[24] implemented a comprehensive ICEP in a specialized preschool setting and reported a significant decrease in the number of total illnesses per child per month, as well as in the number of physician office visits, courses of antibiotics, and days of school missed. However, Krilov et al did not examine the effects of the comprehensive ICEP on emergency department visits, hospitalizations, or productivity losses for parents. To perform an economic assessment that included these factors, we developed an economic model in which we supplemented the actual observed (measured) data reported by Krilov et al with other data estimates derived from the medical literature and a clinical expert panel. The present analysis investigates the extent to which the observed decreases in medical resource utilization and in productivity losses for parents offset the costs of the ICEP. Additional analyses were performed using infection rates from other ICEP studies to assess the economic impact of a less intensive ICEP in a nonspecialized DCC.[21,25–28]

METHODS

Background

The current economic evaluation incorporates clinical data collected during a prospective study by Krilov et al[24] of a comprehensive ICEP in a specialized preschool for children with Down syndrome. The study by Krilov et al was approved by an academic hospital institutional review board, the executive board of the preschool, and parents of participating children in the form of written informed consent. The comprehensive ICEP, which was designed in accordance with the American Public Health Association and the American Academy of Pediatrics guidelines,[29] consisted of a site assessment; in-service educational training for teachers and aides every 4 to 6 weeks; an increased emphasis on handwashing, environmental cleaning, and disinfection with Lysol-brand products (Reckitt Benckiser, Montvale, NJ); and compliance monitoring. As part of the educational program, teachers were instructed to remove toys from use until cleaned if they were seen being mouthed by a child. A cleaning service was hired at an annual cost of $69 354 to decontaminate all toys 3 times per week. During the baseline year, the school's current infection control (IC) procedures were unchanged; during the following intervention year, the ICEP was implemented. At 3-month intervals during both the baseline and intervention years, questionnaires were completed by parents to describe their children's illnesses, medical resource utilization (eg, physician visits, antibiotic usage), and days absent from school as a result of illnesses unrelated to Down syndrome.

The children observed during the 2 years of the study (33 children during the baseline year and 38 during the intervention year) were comparable in terms of demographic and clinical parameters (Table 1),[24] and the distribution of children by grade was similar across the 2 years. In addition, the children who agreed to participate in this study did not differ in terms of age distribution and absence rates relative to the 100 to 110 children at the preschool during the 2-year study period (L.R.K., personal communication). The infection rates in the baseline year were similar to rates reported in previous studies in other populations during similar[25] and other[4–6] time periods. Compliance with infection control practices was measured through the use of an on-site monitor. Compliance was generally consistent throughout the course of the intervention year. The overall compliance rate per classroom was 87.2% ± 4.5%, with a mean of 780 ± 214 observations of compliance per room during the intervention year.[24]

In the intervention year (the year in which the comprehensive ICEP was implemented), the total illness rate decreased by 24% relative to the baseline year (from 0.70 illnesses per child per month to 0.53 illnesses per child per month; $P < .05$; Table 2).[24] In addition, statistically significant reductions in physician visits for illnesses ($P < .05$), courses of antibiotics ($P < .05$), and absences from preschool ($P < .05$) were observed in the intervention year (Table 2).[24] Krilov et al monitored isolation rates of different viruses recovered from community inpatient and outpatient settings that were submitted to a hospital-based diagnostic laboratory over the 2-year study period. The overall rates of viral isolation in the community were not significantly different between years, with the exception of the rate for adenovirus, which was higher in the intervention year ($P < .001$),[24] suggesting that the reductions seen in the intervention year were not a result of a decrease in infection rates in the community during the 2-year period.

Framing the Economic Analysis

In this study, we developed a decision-analytic Markov model with 5 health states using DATA (version 3.5; TreeAge Software, Inc, Williamstown, MA) to simulate the mean annual costs of illness per child in the baseline year (current IC practices) and intervention year (comprehensive ICEP; Fig 1). A Markov model is a recursive decision tree and is useful when a decision involves repetitive events, such as infections.[30] Two clinicians who specialize in pediatric infectious diseases (P.H.D., L.R.K.) provided the clinical framework for the model and made final decisions on derived data estimates. This research was performed according to the guidelines that have been established to minimize conflict of interest in pharmacoeconomic studies.[31,32]

Two economic assessments were conducted. In the primary analysis, we evaluated the extent to which decreased total annual costs of illness (direct medical costs plus costs associated with lost parental working time) in the specialized preschool offset the annual costs of implementing the comprehensive ICEP. In the secondary analysis, we performed a similar evaluation for a nonspecialized preschool with a less intensive ICEP. Both analyses were conducted from the societal perspective and considered all relevant costs and benefits regardless of who incurred the costs or accrued the benefits (eg, patient, physician, payer). Because costs were enumerated over a 1-year time interval, discounting costs was unnecessary. All results were expressed in 1999 US dollars. To assess the external validity and generalizability of our results, we performed "sensitivity analyses" by varying data estimates within a reasonable range and exploring the impact of these variations on the results and inferences.[33]

Five health states and their associated direct medical costs (eg, physician office visits) and indirect costs (productivity losses for parents) were included in the model. The 5 health states were well,

TABLE 1. Characteristics of Children in a Specialized Preschool Research Study

Parameter*	Baseline Year (Current IC Practices)	Intervention Year (Comprehensive ICEP)
Number of participants	33	38
Mean age ± SD (mo)	38.3 ± 15.2	41.6 ± 15.5
Participants' first year in the program	21%	32%
Mean number of siblings	1.1 ± 0.96	1.1 ± 0.93
Cardiopulmonary disease	30%	24%
Toilet trained	91%	97%
Travel on school bus	82%	66%
Have own room	76%	68%
Parents smoke	12%	21%
Additional day care	3%	8%

SD indicates standard deviation.
* No statistically significant differences between groups.
Adapted from Krilov et al.[24]

TABLE 2. Rates of Illnesses and Medical Resource Use per Month in a Specialized Preschool Research Study

Illness	Baseline Year (Current IC Practices)	Intervention Year (Comprehensive ICEP)	P Value
Total illnesses	0.70	0.53	<.05
Respiratory*	0.67	0.42	<.07
Gastrointestinal*	0.08	0.0	NS
Otitis media*	0.08	0.08	NS
Sinusitis*	0.0	0.0	NS
Physician visits	0.50	0.33	<.05
Antibiotic courses	0.33	0.28	<.05
Days absent from school	0.75	0.40	<.05

NS indicates not statistically significant.
* Monthly rates used in the primary analysis.
Adapted from Krilov et al.[24] Rates of illnesses are expressed as median rates per child per month.

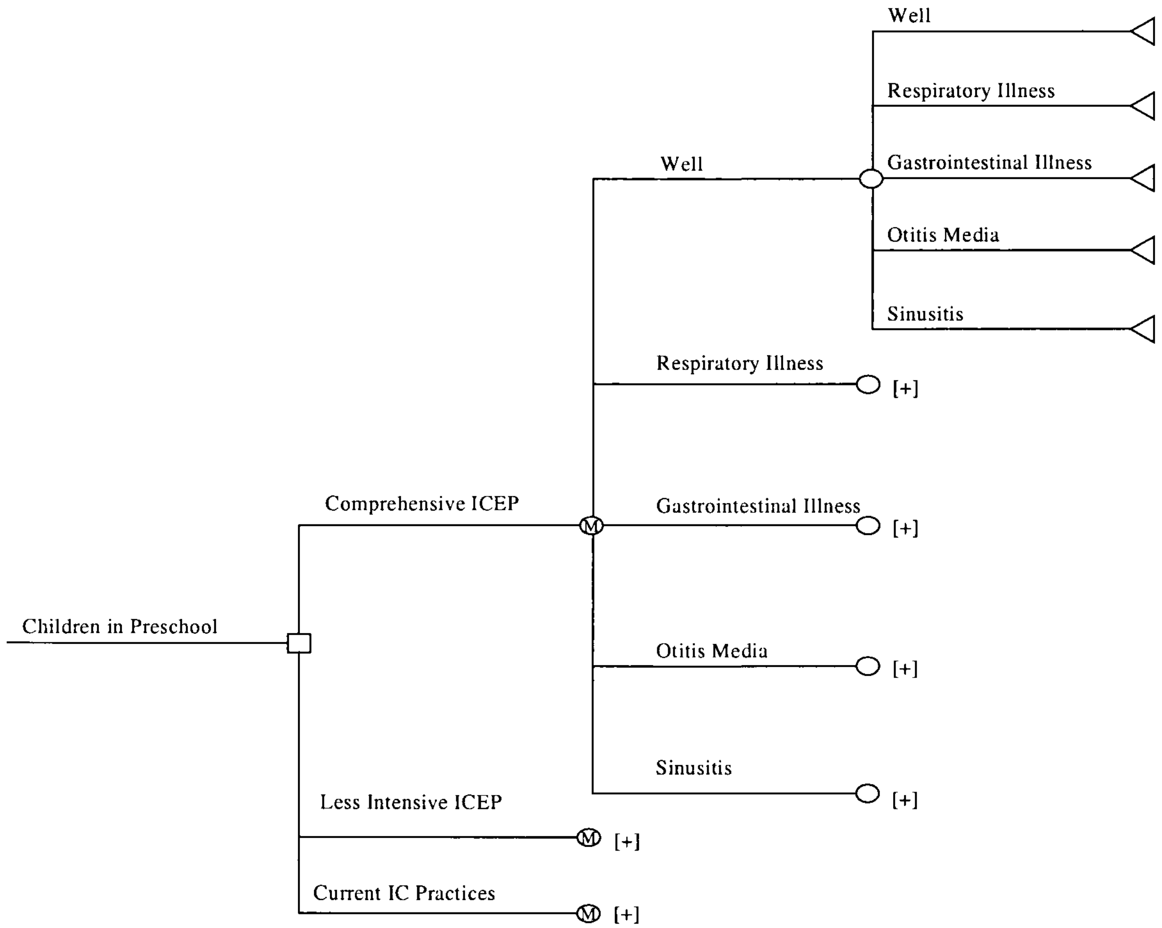

Fig 1. Simplified schematic of economic model. The square node represents a decision to implement 1 of 3 programs for limiting cases of infectious disease in a DCC: a comprehensive ICEP, a less intensive ICEP, or current IC processes and procedures. M denotes a Markov node, indicating entry into a Markov tree, and circles represent chance nodes. The branches that emanate from the comprehensive ICEP arm are duplicated on the less intensive ICEP and the current IC practices arms, as symbolized by +. Once a program option is implemented, hypothetical children enter a Markov tree, which represents the health states in which children may exist during each cycle (each cycle = 1 month). A child either is well or experiences 1 of the listed infectious diseases. Each terminal branch (denoted with a triangle) ends in a health state to which the child returns to begin the next monthly cycle. A child remains in the model for 12 cycles (1 year). Respiratory illness = common cold, pharyngitis, bronchitis, croup, bronchiolitis, and pneumonia.

respiratory illness, gastrointestinal illness, otitis media, and sinusitis. With each 1-month cycle period, children could contract 1 of these illnesses and incur the corresponding cost of that illness. The 1-month time interval is long enough to capture significant events and short enough to be sensitive to cost differences over time.

For the primary analysis (specialized preschool with a comprehensive ICEP), transition probabilities (probabilities of passing from 1 health state to another), physician office visits for illnesses, antibiotic use, and days absent from school were derived from Krilov et al.[24] Data estimates for emergency department visits, hospitalizations, and lost parental working time were derived from a comprehensive literature review[18,25,34–43] and a clinical expert panel (Table 3). These clinical and economic data were modified, as described below, for the secondary analysis (nonspecialized preschool with a less intensive ICEP).

Relevant literature was identified by searching the Medline and Embase databases for articles from 1966 to the present, using keyword terminology for infectious diseases, infection control, and economics. The search was limited to articles in English and excluded review articles, letters, and editorials. Reference lists from retrieved articles also were reviewed. When estimates or assumptions were equivocal after having reviewed the available literature, we chose the one that would bias the results against the ICEP.

Derivation of Costs

Costs were assessed from the societal perspective and included direct medical costs, in addition to costs associated with lost parental working time and the ICEP. Table 4 lists the mean costs per episode of illness in a specialized preschool, which include both direct medical costs and indirect costs associated with lost parental working time.

Direct Medical Costs

To estimate direct medical costs, the clinical panel reviewed the published literature and enumerated medical resource utilization associated with each illness. A physician experienced in medical reimbursement assigned the appropriate *International Classification of Diseases, Ninth Revision, Clinical Modification*, *Current Procedural Terminology*, or diagnosis-related group codes to all hospitalizations, emergency department visits, physician office visits, laboratory tests, and professional services. Laboratory test costs were from the 1999 Clinical Laboratory Information Act Fee Schedule. We then derived cost estimates for each code from 1999 national Medicare reimbursement schedules. Drug costs were estimated from the *Drug Topics Red Book*, a listing of wholesale drug prices in the United States.[44] We deducted 20% from the average wholesale price to obtain a more accurate estimate of actual drug costs.[45]

Costs of Lost Parental Working Time

Productivity losses for parents were quantified using the number of days a child was absent as a result of illness. Lost parental working time was estimated using 2 methods, the opportunity cost method and the replacement cost method. The opportunity cost method values parents' time according to the value of the

TABLE 3. Resource Utilization per Illness in a Specialized Preschool

Illness	Illness Distribution	Probability of Physician Office Visit*	Probability of Antibiotic Prescription	Probability of Emergency Department Visit	Probability of Hospitalization	Probability of Day Care Absence as a Result of Illness**	Average Number of Days Absent
Respiratory	—						
Common cold	86%	10%	30%§	0%	0%	7.5%	2
Pharyngitis	3%	50%†	50%‖	0%	0%	50%	2
Bronchitis	3%	25%	50%§	0%	0%	50%	3
Croup	2%	80%	15%§¶	5%	2%	50%	3
Bronchiolitis	3%	90%	50%§	5%	2%	90%	5
Pneumonia	3%	80%‡	100%§	5%	2%	100%	5
Gastrointestinal	—	33%	10%	10%	5%	90%	3
Otitis media	—	100%	100%	0%	0%	100%	2
Sinusitis	—	100%	100%	0%	0%	100%	2

From Krilov et al,[24] the Medical Literature, and Clinical Expert Opinion.
* For each illness, we assumed that there would be 2 visits (initial visit and follow-up visit).
† For children with pharyngitis, we assumed that 100% would have a rapid strep test and 20% would have a β-strep culture.
‡ For children with pneumonia, we assumed that 80% of the children would receive a chest x-ray.
§ Type, distribution, and dosage of antibiotics: amoxicillin (40%), Augmentin (15%), Zithromax (20%), Biaxin (12.5%), and cephalosporins (12.5%). The dosing regimens we costed were as follows: amoxicillin, 250 mg 3 times a day for 10 days; Augmentin, 500 mg twice a day for 10 days; Zithromax, 10 mg/kg day 1, 5 mg/kg days 2–5; Biaxin, 7.5 mg/kg twice a day; and cephalosporins, 7.5 mg/kg twice a day.
‖ Distribution of antibiotics: amoxicillin (100%).
¶ In addition to antibiotics, we assumed that 100% of patients received dexamethasone acetate (0.6 mg/kg day 1).
** When a child was absent from day care, it was assumed that the child was cared for at home.

TABLE 4. Mean Costs per Episode of Illness in a Specialized Preschool*

Illness	Cost (1999 US Dollars)
Respiratory†	$76
Common cold	$24
Pharyngitis	$159
Bronchitis	$179
Croup	$291
Bronchiolitis	$624
Pneumonia	$693
Gastrointestinal	$459
Otitis media	$301
Sinusitis	$301

* Mean costs include both direct medical costs and indirect costs associated with lost parental working time.
† Distribution of respiratory illness: common cold (86%), pharyngitis (3%), bronchitis (3%), croup (2%), bronchiolitis (3%), and pneumonia (3%).

time in its next-best alternative use. Under this method, the opportunity cost is represented by the parents' lost wages.[46] Therefore, using the opportunity cost method, we applied a national average wage rate ($117 per day) to work days missed.[47] We also assumed that an alternative caregiver (eg, a babysitter) would care for the sick child approximately 20% of the time and costed these services at half the national wage rate. For the replacement cost method, we valued the lost time for parents as the amount that parents would need to pay a caregiver without specialized training (costed at half the national average wage rate).[46]

ICEP Costs

The resources associated with the ICEP as it was implemented in the specialized preschool setting were obtained from Reckitt Benckiser, the sponsor of the preschool study. Resources included 1) personnel to conduct the initial assessment, in-service training, and compliance monitoring; 2) a contract cleaning service to clean the toys; 3) cleaning and disinfecting products; and 4) educational materials such as posters and handouts. The costs of these resources were based on the actual costs paid during the study (cleaning service costs), actual or national wage rates (personnel costs), and national average retail prices less a discount factor (30%; to obtain a more accurate estimate of cleaning product costs). We assumed that the cost of current IC procedures performed during the baseline year consisted of a minimal amount of cleaning products (25% of the cleaning product volume and costs used in the intervention year). Costs were inflated, as necessary, to 1999 dollars using either the all-items component or the medical care services component of the consumer price index, as appropriate.[47]

Economic Analyses

Two analyses were performed. The primary analysis evaluated the economic impact of a comprehensive ICEP in a specialized preschool; the secondary analysis evaluated the economic impact of a less intensive ICEP in a nonspecialized preschool.

Primary Analysis: Specialized Preschool With Comprehensive ICEP

The primary analysis included data reported by Krilov et al (eg, physician office visits, antibiotic use), in addition to parameter estimates derived from the literature and clinical expert opinion (eg, emergency department visits and hospitalizations). The external validity and generalizability of the results were assessed using 1-way sensitivity analyses and several analyses in which multiple parameters were varied over plausible ranges. Specifically, sensitivity analyses were conducted to determine the consequences of making alternative assumptions about infection rates, primary caregivers (parent versus babysitter), inclusion of over-the-counter (OTC) products, the maximum number of illnesses per month, the distribution of specific respiratory illnesses, the method for costing lost productivity for parents, and the wage rate for the primary caregiver.

Secondary Analysis: Nonspecialized Preschool With Less Intensive ICEP

The comprehensive ICEP implemented by Krilov et al[24] was designed to maximize the potential impact on infectious disease rates, not necessarily to reflect a program that was likely to be implemented broadly in DCCs. In addition, the study was conducted in a specialized preschool setting with a specific student population (Down syndrome). These 2 factors would limit the generalizability of this economic assessment. Therefore, we conducted a secondary analysis in which we varied numerous parameters simultaneously (relative to the specialized preschool analysis)—for example, we excluded the cleaning service, reduced cleaning and disinfecting product use by 25%, decreased baseline rates of illness from Krilov et al by 10%, decreased ICEP effectiveness by 25%, and reduced medical resource utilization (physician office visits, emergency department visits, and hospitalizations) by 50%—to reflect a less intensive ICEP in a more generalizable setting (nonspecialized preschool). These assumptions were informed by the medical literature and a clinical expert panel. We hypothesized that in this setting, teachers would perform those tasks completed by the cleaning service in the study by Krilov et al, which would reduce the effectiveness of the program. We also hypothesized that a non–Down syndrome population would have fewer follow-up visits and would be less likely to be admitted to the hospital. Sensitivity analyses were conducted to determine the consequences of making alternative assumptions about the analysis perspective (societal versus household), infection rates, the method for costing lost productivity for parents, and the wage rate for the primary caregiver.

RESULTS

Primary Analysis: Specialized Preschool With Comprehensive ICEP

With a comprehensive ICEP, the mean cost of illness in the baseline year was $1235 per child, of which 68% and 14% were for productivity losses and physician visits, respectively (Table 5, Fig 2). In the intervention year, the mean cost of illness per child was $615, of which 71% and 20% were for productivity losses and physician visits, respectively. Hence, the annual cost-of-illness savings were $620 per child, or roughly 50% of the mean cost of illness per child.

The cost of IC practices in the baseline year was $716. The comprehensive ICEP cost (intervention year) was $75 627, 92% of which was spent to hire a cleaning service to decontaminate toys 3 times per week. The remaining 8% ($6273) of the ICEP cost was distributed roughly evenly between training and cleaning supplies.

To determine the extent to which the costs of the comprehensive ICEP were offset by reduced costs of illness, we compared the incremental program cost with the total cost savings from reduced rates of infection (adjusted to 38 children in the DCC). The total savings ($23 560) offset 31% of the incremental cost of the comprehensive ICEP ($74 911; Table 6).

Sensitivity analyses for the specialized preschool setting demonstrated that the incremental cost of illness was fairly insensitive to changes in baseline infection rates, the caregiver distribution (parent versus babysitter), inclusion of OTC products, the number of infections possible per month, the respiratory illness distribution, the approach for costing lost productivity, and the wage rate for the primary caregiver (Table 7). In these scenarios, the cost savings represented 47% to 53% of the mean annual costs of illness per child in the baseline year, compared with 50% based on the primary analysis.

Secondary Analysis: Nonspecialized Preschool With Less Intensive ICEP

When a secondary analysis was performed to reflect a less intensive ICEP in a nonspecialized preschool setting, the mean costs of illness in the baseline and intervention years were $962 and $614, respectively, representing a 36% decline (Fig 2). The cost of the IC practices in the baseline year was $716, whereas the cost of the less intensive ICEP was $3087. Therefore, the incremental cost of the less intensive ICEP was $2371, whereas the cost savings per child as a result of fewer episodes of illness were $348. For 38 children in a nonspecialized DCC, the annual net savings were estimated to be $10 853 (total cost savings from reduced illness minus the incremental cost of the less intensive ICEP; Table 6).

We also performed a threshold analysis to determine how effective (what percentage reduction in infection rates) a less intensive ICEP would have to be to result in cost neutrality (the point at which incremental program costs equal the reduction in the total costs of illness). Because respiratory disease is the most prevalent of the infectious diseases in a preschool setting, we took the conservative and simplifying approach that the ICEP would have an impact only on rates of respiratory disease. The analysis demonstrated that for 38 children in a DCC, a 12.8% reduction in respiratory disease rates would be necessary for the less intensive ICEP to be cost-neutral from the societal perspective.

Although the societal perspective is often recommended for economic analyses,[48,49] analyses from other perspectives also are informative. Therefore, we conducted a sensitivity analysis for the less intensive ICEP in a nonspecialized preschool from a household perspective. This perspective incorporated only medical copayments/coinsurance and other out-of-pocket expenditures (eg, OTC products, babysitting costs) to determine the costs of infectious disease to the household whose children attend a preschool. The mean annual costs of illness per child for the baseline and intervention years were $176 and $113, respectively (Table 7), representing a 36% decline. The resulting cost-of-illness savings ($63 per child per year) seem to be sufficient to pay for the ICEP should the entire ICEP cost be passed on to parents through higher tuition payments (incremen-

TABLE 5. Mean Annual Costs of Illness per Child in the Baseline and Intervention Years in a Specialized Preschool (1999 US Dollars)*

Cost Category	Baseline (Current IC Practices)	Intervention Year (Comprehensive ICEP)	Cost Savings
Total	$1235 (100%)	$615 (100%)	$620 (100%)
Inpatient and emergency department	$178 (14%)	$27 (4%)	$151 (24%)
Outpatient	$177 (14%)	$121 (20%)	$56 (9%)
Lost productivity	$845 (68%)	$439 (71%)	$406 (65%)
Prescription drugs	$27 (2%)	$22 (4%)	$5 (1%)
Laboratory and other diagnostic tests	$8 (1%)	$5 (1%)	$3 (1%)

* Means were calculated using a hypothetical cohort of 1000 children. Percentage of total costs are given in parentheses. Column percentages may not add to 100% as a result of rounding.

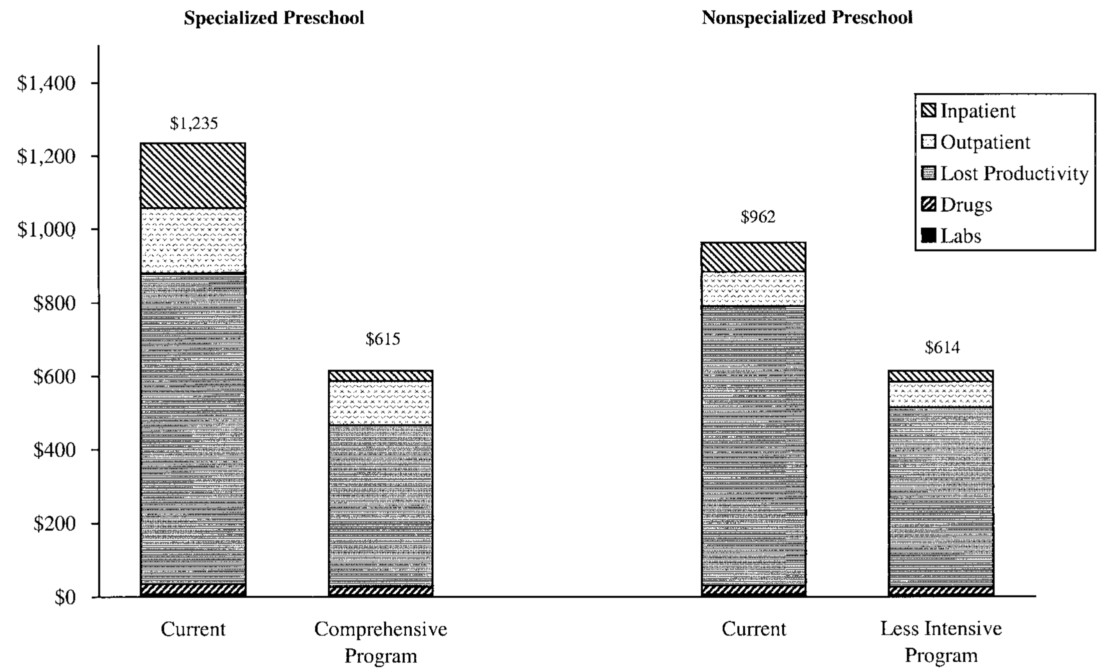

Fig 2. Mean annual costs of illness per child (1999 US dollars). Costs of illness (direct medical costs plus indirect costs of lost productivity), from a societal perspective, are presented during baseline and intervention years for a specialized preschool for children with Down syndrome (primary analysis) and a nonspecialized preschool (secondary analysis). In the primary analysis, disease incidence rates were based on data in Table 2 (from Krilov et al). For the secondary analysis, we decreased baseline disease incidence estimates from Krilov et al by 10%; reduced cleaning and disinfecting product use and costs by 25%; decreased the overall effectiveness of the ICEP by 25%; decreased the number of physician office visits, emergency department visits, and hospitalizations by 50%; and excluded the cleaning service for the toys.

TABLE 6. Annual Savings Potentially Attributable to ICEP (1999 US Dollars)

	Specialized Preschool*			Nonspecialized Preschool†		
	Current IC Practices	Comprehensive ICEP	Net Cost (Savings)	Current IC Practices	Less Intensive ICEP	Net Cost (Savings)
Costs of illness‡	$46 930	$23 370	($23 560)	$36 556	$23 332	($13 224)
IC costs for entire DCC	$716	$75 627	$74 911	$716	$3087	$2371
Total costs						
Per 38 children‡	—	—	$51 351	—	—	($10 853)
Per child	—	—	$1351	—	—	($286)

* Preschool setting with a Down syndrome population (primary analysis).
† Preschool setting with a non–Down syndrome population (secondary analysis).
‡ Costs (direct medical costs plus costs associated with lost parental working time) for 38 children (the number that participated in the specialized preschool research study by Krilov et al[24]).

tal program cost [$2371] divided by 38 children in the DCC = $62.39 per child per year).

Other investigators have evaluated the clinical impact of less intensive ICEPs in DCCs. We conducted a sensitivity analysis by incorporating the illness rates (number of illnesses, by type, per child per month) reported in 5 of these papers to estimate the economic impact of illness reduction in these studies.[21,25–28] We acknowledge that there are many differences among the studies, such as different study designs, DCCs, IC programs, and age distributions. For example, the mean ages in the Krilov, Uhari, Carabin, Kotch, and Roberts studies were roughly 40, 42, 26, 16, and 24 months, respectively.[21,24–28] Nevertheless, we conducted these analyses primarily to assess the range of potential cost-of-illness savings that may be achieved by implementing a less intensive ICEP in a nonspecialized DCC.

When the costs of illnesses from our economic analysis were applied to the infection rates reported in the Uhari, Carabin, Kotch, and Roberts studies, the annual cost savings per child were $188 (19%), $387 (32%), $206 (8%), and $335 (20%), respectively (Table 7).[21,25–28] The rates of infection and, therefore, total costs of illness were highest in the youngest population ($2604 in the baseline year), yet the reduction in rates of illness and costs were lowest (8%) in this group. Overall, these cost-of-illness savings are similar in magnitude to the cost-of-illness savings derived from our secondary analysis that reflected a less intensive ICEP ($348 per child per year, or 36%). It is worth noting that the Uhari, Carabin, Kotch, and Roberts studies were performed in non–Down syndrome populations with interventions similar to the less intensive ICEP that we simulated in our secondary analysis.

TABLE 7. Sensitivity Analysis Results: Mean Annual Costs of Illness per Child (Direct Medical Costs Plus Costs Associated With Lost Parental Working Time; 1999 US Dollars)

Parameter	Baseline Year (Current IC Practices)	Intervention Year (ICEP)	Cost Savings
Primary analysis (specialized preschool with comprehensive ICEP from a societal perspective)	$1235	$615	$620
Infection rates			
Increase by 10%	$1379	$684	$695
Decrease by 10%	$1090	$558	$532
Caregiver for ill child*			
Parent:babysitter—60:40	$1142	$566	$576
Parent:babysitter—100:0	$1329	$664	$665
Inclusion of OTC drugs	$1257	$627	$630
Allow for 2 illnesses per child per month†	$1290	$642	$648
Distribution of respiratory illnesses‡			
Decrease common cold, increase others	$1621	$858	$763
Increase common cold, decrease others	$1043	$493	$550
Replacement cost method for lost productivity§	$860	$420	$440
Wage rate for primary caregiver			
Increase by 20%	$1404	$703	$701
Decrease by 20%	$1066	$527	$539
Secondary analysis (nonspecialized preschool with less intensive ICEP from a societal perspective)‖	$962	$614	$348
Household perspective¶	$176	$113	$63
Using rates of illness from other ICEP studies#			
Uhari et al (1999)[25]	$1002	$814	$188
Carabin et al (1999)[26]	$1212	$825	$387
Kotch et al (1994)[21]	$2604	$2398	$206
Roberts et al (2000)[27,28]	$1672	$1337	$335
Replacement cost method for lost productivity§	$625	$398	$227
Wage rate for primary caregiver			
Increase by 20%	$1114	$711	$403
Decrease by 20%	$810	$516	$294

* In the primary analysis, parents were assumed to care for an ill child 80% of the time, and a babysitter was assumed to care for the child during the remaining 20%.

† In the primary analysis, we assumed that a child could develop a maximum of 1 illness per month. In this analysis, we allowed children to develop up to 2 illnesses per month.

‡ In the primary analysis, we assumed the average distribution of respiratory illness—common cold, pharyngitis, bronchitis, croup, bronchiolitis, and pneumonia—to be 86%, 3%, 3%, 2%, 3%, and 3%, respectively; in the first sensitivity analysis to be 72%, 6%, 6%, 4%, 6%, and 6%, respectively (decreased common cold); and in the second sensitivity analysis to be 93%, 1.5%, 1.5%, 1%, 1.5%, and 1.5%, respectively (increased common cold).

§ Lost time for parents was valued as the amount that parents would need to pay a caregiver without specialized training (costed at half the national average wage rate).

‖ The following modifications were made to parameters from the primary analysis to reflect a less comprehensive ICEP in a preschool setting with a non–Down syndrome population: decrease the rate of illness in baseline year by 10%; reduce cleaning and disinfecting product use and costs by 25%; decrease the overall effectiveness of the ICEP by 25%; decrease the number of physician office visits, emergency department visits, and hospitalizations by 50%; and exclude the cleaning service for the toys.

¶ The following cost estimates were modified from the secondary analysis to reflect the out-of-pocket costs of a household whose children attend a preschool: physician office visits (copayment $10); emergency department visits (copayment $50); antibiotics (copayment $15); OTC for common cold and viral gastroenteritis ($3 per episode); and hospitalization ($1000 deductible).

For use in the economic model, rates were converted to number of illnesses, by type, per child per month.

DISCUSSION

To the best of our knowledge, this study is the first to evaluate the economic impact of a multidimensional ICEP in the day care setting. We compared the annual costs of an ICEP to the associated reduction in the costs of illness. Our results suggest that in a nonspecialized day care setting, the reduction in the costs of illness more than offsets the cost of implementing the less intensive ICEP. When extrapolated to the 100 children in the entire DCC evaluated by Krilov et al, the potential societal savings of a less intensive ICEP are estimated at $32 500 annually.

When extrapolated to the 3 million US children who are younger than 5 years and who attend a DCC, the potential societal savings are estimated at $974 million annually, offsetting roughly 70% of the excess costs associated with increased risk of illness in DCCs.[15] These potential societal savings may be underestimated, because we did not consider costs associated with secondary infections in parents, siblings, or DCC personnel. Nor did we consider the potential savings associated with exercising IC practices in the 15.5 million households with children under the age of 6.[50]

We estimated the total annual costs of illness per child in a nonspecialized DCC at $962 with current IC practices. These costs are within the range reported previously by Bell et al and Carabin et al ($1425 and $557, respectively).[7,36] In addition, our estimated costs of episodes of gastrointestinal illness and otitis media were $374 and $271, respectively, in a nonspecialized preschool. Other investigators have estimated the cost of an episode of gastrointestinal illness to be from $311 to $409 and the cost of otitis media to be $138.[34,40,51] The differences in the costs of illness reported in these studies are attributable largely to including different direct medical costs or indirect costs in the analysis. These costs have been adjusted to 1999 US dollars using the medical care component of the consumer price index.

Our study demonstrated that the cost associated with a parent's missing work was substantial and accounted for roughly 70% of the mean annual costs of illness per child. Other investigators also have reported that lost productivity is the single most expensive cost category.[7,34,36,40,51,52]

As with any model-based approach, the results are only as good as the underlying assumptions. Our primary analysis applies only to children in a specialized DCC with a comprehensive ICEP. We addressed this limitation by varying our assumptions in a secondary analysis to reflect a less intensive ICEP in a nonspecialized DCC. Although we based our assumptions on published literature and a consensus panel and, therefore, believe that our assumptions are reasonable, this secondary analysis warrants additional comment. Our results suggest that the costs of the less intensive ICEP in a nonspecialized DCC are more than offset by the reduction in the costs of illness. When the illness rates from other studies were incorporated into the economic model, the reduction in the costs of illness was similar to our secondary analysis, suggesting that our assumptions were reasonable.

Other study limitations are worth mentioning. Because the study by Krilov et al[24] was not aimed at determining which parts of the intervention program were responsible for the reduction in rates of illness, any or all of the following components could have contributed to the reduction: education, handwashing, surface cleaning, toy cleaning, or ongoing monitoring. (In fact, the presence of study personnel, including the toy cleaning service that was present 3 times per week, may have contributed to the educational component of the program and modified the behavior of the DCC's staff.[18]) In addition, although Krilov et al[24] was a longitudinal study, Uhari and Möttönenn[25] collected their data during the same years and observed similar rates of illness, partially addressing the concern over year-to-year variability in infection rates. Furthermore, although the mean age in Krilov et al was somewhat older than the age at which infections peak in children in DCCs, the nature of children with Down syndrome and their increased risk of infection[53] could have contributed to observing rates of illness similar to those reported by Uhari and Möttönenn[25] for children without special needs. In addition, although there were some children who participated in the study by Krilov et al during both years, there also were many children during the second year who were new to the DCC, thereby helping to minimize any bias. Last, medical records in Krilov et al were not reviewed to validate the parents' responses on the questionnaires about their children's illnesses. Nevertheless, we expect that any underreporting would have been similar between the baseline and intervention years, thereby affecting the magnitude of rather than the difference in illness rates and costs.

Our results demonstrate the need to increase awareness among DCC personnel about the importance of education, handwashing, disinfecting, and cleaning. Such hygienic practices also could help decrease absences of DCC personnel. Furthermore, because the costs of ICEPs will need to be passed on to parents in the form of higher DCC fees, educational programs will be necessary to educate parents about the clinical benefits (reduced illness) and financial benefits (reduced medical costs and lost working time) of ICEPs.

Multidimensional ICEPs can help ensure that children in DCCs are in safe and healthful environments. Our research suggests that such programs could have substantial clinical and economic benefits to both families and society; however, these benefits can be fully realized only through effective educational programs that communicate these benefits to parents, DCC personnel, and policy makers.

ACKNOWLEDGMENTS

Research support was provided by Reckitt Benckiser.

We thank Donna J. Gaber, MT, and Joseph R. Rubino, MA, from Reckitt Benckiser for providing details about the ICEP in the specialized preschool research study. We also thank John Carlsen and Holly Bonello from Covance Health Economics and Outcomes Services Inc for assistance with manuscript preparation.

REFERENCES

1. Smith K. *Who's Minding the Kids? Child Care Arrangements: Fall. 1995. Current Population Reports: P70–70*. Washington, DC: US Census Bureau; 2000:5
2. Office of the Press Secretary. *The Bush Administration FY2002 Budget. A Blueprint for New Beginnings—A Responsible Budget for America's Priorities*. Washington, DC: US Government Printing Office; 2001
3. Thacker SB, Addiss DG, Goodman RA, Holloway BR, Spencer HC. Infectious diseases and injuries in child day care: opportunities for healthier children. *JAMA*. 1992;268:1720–1726
4. Wald ER, Guerra N, Byers C. Frequency and severity of infections in day care: three-year follow-up. *J Pediatr*. 1991;118:509–514
5. 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
6. Reves RR, Morrow A, 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
7. Bell DM, Gleiber DW, Mercer AA, et al. Illness associated with child day care: a study of incidence and cost. *Am J Public Health*. 1989;79:479–484
8. Fleming DW, Cochi SL, Hightower AW, Broome CV. Childhood upper respiratory tract infections: to what degree is incidence affected by day-care attendance? *Pediatrics*. 1987;79:55–60
9. Louhiala PJ, Jaakkola N, Ruotsalainen R, Jaakkola JJK. Form of day care and respiratory infections among Finnish children. *Am J Public Health*. 1995;85:1109–1112
10. Anderson LJ, Parker RA, Strikas RA, et al. Day-care center attendance and hospitalization for lower respiratory tract illness. *Pediatrics*. 1988; 82:300–308
11. Hardy AM, Fowler MG. Child care arrangements and repeated ear infections in young children. *Am J Public Health*. 1993;83:1321–1325
12. The Child Day Care Infectious Disease Study Group. Public health considerations of infectious diseases in child day care centers. *J Pediatr*. 1984;105:683–701
13. Nafstad P, Hagen JA, Oie L, Magnus P, Jaakkola JJK. Day care centers and respiratory health. *Pediatrics*. 1999;103:753–758
14. Meissner HC. Economic impact of viral respiratory disease in children. *J Pediatr*. 1994;124:S17–S21
15. Haskins R. Acute illness in day care: how much does it cost? *Bull N Y Acad Med*. 1989;65:319–343
16. US Department of Labor, Bureau of Labor Statistics, Consumer Price Index—All Urban Consumers, US City Average, Medical Care. Available: http://www.stats.bls.gov/top20.html 1999. Accessed March 7, 2000
17. Black RE, Dykes A, Anderson KE, et al. Handwashing to prevent diarrhea in day-care centers. *Am J Epidemiol*. 1981;113:445–451
18. Bartlett A, Jarvis BA, Ross V, et al. Diarrheal illness among infants and toddlers in day care centers: effects of active surveillance and staff

training without subsequent monitoring. *Am J Epidemiol*. 1988;127:808–817
19. Butz AM, Larson E, Fosarelli P, Yolken R. Occurrence of infectious symptoms in children in day care homes. *Am J Infect Control.* 1990;18:347–353
20. Van R, Wun C-C, Morrow AL, Pickering LK. The effect of diaper type and overclothing on fecal contamination in day-care centers. *JAMA.* 1991;265:1840–1844
21. Kotch JB, Weigle KA, Weber DJ, et al. Evaluation of an hygienic intervention in child day-care centers. *Pediatrics.* 1994;94(6 Pt 2):991–994
22. Holaday B, Waugh G, Moukaddem VE, West J, Harshman S. Fecal contamination in child day care centers: cloth vs paper diapers. *Am J Public Health.* 1995;85:30–33
23. Holaday B, Waugh G, Moukaddem VE, West J, Harshman S. Diaper type and fecal contamination in child day care. *J Pediatr Health Care.* 1995;9:67–74
24. Krilov LR, Barone SR, Mandel FS, Cusack TM, Gaber DJ, Rubino JR. Impact of an infection control program in a specialized preschool. *Am J Infect Control.* 1996;24:167–173
25. Uhari M, Möttönenn M. An open randomized controlled trial of infection prevention in child day-care centers. *Pediatr Infect Dis J.* 1999;18:672–677
26. Carabin H, Gyorkos TW, Soto JC, Joseph L, Payment P, Collet JP. Effectiveness of a training program in reducing infections in toddlers attending day care centers. *Epidemiology.* 1999;10:219–227
27. Roberts L, Smith W, Jorm L, Patel M, Douglas RM, McGilchrist C. Effect of infection control measures on the frequency of upper respiratory infection in childcare: a randomized, controlled trial. *Pediatrics.* 2000;105:738–742
28. Roberts L, Jorm L, Patel M, Smith W, Douglas RM, McGilchrist C. Effect of infection control measures on the frequency of diarrheal episodes in childcare: a randomized, controlled trial. *Pediatrics.* 2000;105:743–746
29. American Public Health Association and the American Academy of Pediatrics. *Caring for Our Children: National Health and Safety Performance Standards: Guidelines for Out-of-Home Child Care Programs*. Ann Arbor, MI: American Public Health Association and the American Academy of Pediatrics; 1992
30. Sonnenberg FA, Beck JR. Markov models in medical decision making: a practical guide. *Med Decis Making.* 1993;13:322–338
31. Hillman AL, Eisenberg JM, Pauly MV, et al. Avoiding bias in the conduct and reporting of cost-effectiveness research sponsored by pharmaceutical companies. *N Engl J Med*. 1991;324:1362–1365
32. Schulman KA, Rubenstein LE, Glick HA, Eisenberg JM. Relationships between sponsors and investigators in pharmacoeconomic and clinical research. *Pharmacoeconomics.* 1995;7:206–220
33. Manning WG, Fryback DG, Weinstein MC. Reflecting uncertainty in cost-effectiveness analysis. In: Gold MR, Siegel JE, Russell LB, Weinstein MC, eds. *Cost-Effectiveness in Health and Medicine.* New York, NY: Oxford University Press; 1996:247–275
34. Avendaño P, Matson D, Long J, Whitney S, Matson CC, Pickering LK. Costs associated with office visits for diarrhea in infants and toddlers. *Pediatr Infect Dis J*. 1993;12:897–902
35. Berman S, Byrns PJ, Bondy J, Smith PJ, Lezotte D. Otitis media-related antibiotic prescribing patterns, outcomes, and expenditures in a pediatric Medicaid population. *Pediatrics.* 1997;100:585–592
36. Carabin H, Gyorkos TW, Soto JC, Penrod J, Joseph L, Collet JP. Estimation of direct and indirect costs because of common infections in toddlers attending day care centers. *Pediatrics.* 1999;103:556–564
37. Chapman RS, Henderson FW, Clyde WA, Collier AM, Denny FW. The epidemiology of tracheobronchitis in pediatric practice. *Am J Epidemiol*. 1981;114:786–797
38. Collet JP, Burtin P, Gillet J, et al. Risk of infectious diseases in children attending different types of day-care setting. *Respiration.* 1994;61(suppl 1):16–19
39. Glezen WP, Loda FA, Clyde WA, et al. Epidemiologic patterns of acute lower respiratory disease of children in a pediatric group practice. *J Pediatr*. 1971;78:397–406
40. Kaplan B, Wandstrat TL, Cunningham JR. Overall cost in the treatment of otitis media. *Pediatr Infect Dis J*. 1997;16:S9–S11
41. Langley JM, Wang EEL, Law BJ, et al. Economic evaluation of respiratory syncytial virus infection in Canadian children: a Pediatric Investigators Collaborative Network on Infections in Canada (PICNIC) study. *J Pediatr*. 1997;131:113–117
42. Perlstein PH, Kotagal UR, Bolling C, et al. Evaluation of an evidence-based guideline for bronchiolitis. *Pediatrics.* 1999;104:1334–1341
43. Wandstrat TL, Kaplan B. Pharmacoeconomic impact of factors affecting compliance with antibiotic regimens in the treatment of acute otitis media. *Pediatr Infect Dis J*. 1997;16:S27–S29
44. *Drug Topics Red Book*. Montvale, NJ: Medical Economics Company Inc; 1999
45. *Medicaid Pharmacy—Actual Acquisition Cost of Prescription Drug Products for Brand Name Drugs*. Washington, DC: Office of Inspector General Reports and Advisory Opinions; 1997
46. Garber AM, Weinstein MC, Torrance GW, Kamlet MS. Theoretical foundations of cost-effectiveness analysis. In: Gold MR, Siegel JE, Russell LB, Weinstein MC, eds. *Cost-Effectiveness in Health and Medicine.* New York, NY: Oxford University Press; 1996:25–53
47. US Department of Labor, Bureau of Labor Statistics. *National Wage Rates*. Washington, DC: US Government Printing Office; 1999
48. Russell LB, Gold MR, Siegel JE, Daniels N, Weinstein MC, for the Panel on Cost-Effectiveness in Health and Medicine. The role of cost-effectiveness analysis in health and medicine. *JAMA*. 1996;276:1172–1177
49. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB, for the Panel on Cost-Effectiveness in Health and Medicine. Recommendations of the panel on cost-effectiveness in health and medicine. *JAMA*. 1996;276:1253–1258
50. US Department of Commerce, Population Division, US Bureau of the Census. Current Population Reports—Household and Family Characteristics. Washington, DC: US Government Printing Office; 1998:1. Report No. P20-515
51. Hardy AM, Lairson DR, Morrow AL. Costs associated with gastrointestinal-tract illness among children attending day-care centers in Houston, Texas. *Pediatrics.* 1994;94(suppl):1091–1093
52. Nurmi T, Salminen E, Pönkä A. Infections and other illnesses of children in day-care centers in Helsinki II: the economic losses. *Infection.* 1991;19:331–335
53. Ugazio AG, Maccario R, Notarangelo LD, Burgio GR. Immunology of Down syndrome: a review. *Am J Med Genet*. 1990;7:204–212

Economic Impact of an Infection Control Education Program in a Specialized Preschool Setting

Stacey J. Ackerman, Steven B. Duff, Penelope H. Dennehy, Michael S. Mafilios and Leonard R. Krilov

Pediatrics 2001;108;e102
DOI: 10.1542/peds.108.6.e102