Impact of the CDC's Section 317 Immunization Grants Program Funding on Childhood Vaccination Coverage

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The Centers for Disease Control and Prevention's Section 317 Grants Program is the main source of funding for state and jurisdictional immunization programs, yet no study has evaluated its direct impact on vaccination coverage rates. Therefore, we used a fixed-effects model and data collected from 56 US jurisdictions to estimate the impact of Section 317 financial assistance immunization grants on childhood vaccination coverage rates from 1997 to 2003.

Our results showed that increases in Section 317 funding were significantly and meaningfully associated with higher rates of vaccination coverage; a $10 increase in per capita funding corresponded with a 1.6-percentage-point increase in vaccination coverage. Policymakers charged with funding public health programs should consider this study's findings, which indicate that money allocated to vaccine activities translates directly into higher vaccine coverage rates. (*Am J Public Health.* 2006;96:1548–1553. doi:10.2105/AJPH.2005.078451)

THE CENTERS FOR DISEASE Control and Prevention's (CDC) Public Health Service Section 317 Immunization Grants Program was established by the Vaccination Assistance Act of 1962 to assist US jurisdictions in purchasing vaccine doses for polio, diphtheria, pertussis, tetanus, and measles (added in 1965).[1] After a series of measles outbreaks between 1988 and 1991, the US Congress modified the program to allow Section 317 funds to support vaccination infrastructure and direct service delivery.[2] In 2002, the Section 317 program allocated $392 million to support vaccine purchases ($216 million) and program operations ($176 million; N. Smith, CDC National Immunization Program, written communication, February 2005).

In 1993, the newly created Vaccines for Children entitlement program supplanted the Section 317 program as the main source of federal vaccine purchase funding. However, Section 317 financial assistance funding remains the primary source of funding for most jurisdictional vaccine program operations. In whole or in part, Section 317 funding supports activities that (1) direct public vaccine provision; (2) oversee provider quality by conducting assessments, training programs, and compliance monitoring; (3) develop immunization registries; (4) support school-based and community-based service delivery programs; (5) create and deliver consumer information; (6) conduct vaccine-preventable disease surveillance; and (7) conduct population needs assessments.[3]

The US vaccination system for children comprises a set of vaccine programs that are managed at the state and jurisdictional levels and are loosely coordinated by federal program managers at the CDC. The financing and provision of vaccines for children is shared by federal, state, and private sources. This decentralized system is similar to that of other industrialized countries, such as Germany and France. In contrast, Great Britain and Finland use fully public and centralized systems in which all vaccines are purchased and distributed by the government and the government is fully responsible for all vaccination program operations. In general, centralized systems are thought to result in higher coverage rates and to be more costly to operate; however, empirical evidence to support this notion is scarce.[4]

Several qualitative studies in the United States have evaluated the importance of Section 317 program activities in relation to the mix of other federal, state, and private efforts to ensure adequate immunization coverage.[5–7] These studies concluded that the activities and operations supported by Section 317 program funds are in fact vital to holding together the decentralized immunization system. However, no quantitative study has evaluated the independent and direct impacts of Section 317 funding on vaccination coverage outcomes.

In our study, we evaluated whether the Section 317 program can be empirically and independently associated with improved coverage outcomes. This was difficult, because Section 317 funding represents only a small portion of a large and interdependent decentralized vaccination system, and because the characteristics of each funded jurisdiction may confound statistical attempts to identify an independent effect. To overcome this difficulty, we used a fixed-effects model that controlled for the jurisdictional characteristics that might otherwise confound or obscure this association.

METHODS

In our general fixed-effects model, immunization was a function of funding after we controlled for important confounding variables:

Immunization was calculated as

$$(1)\quad \text{Immunization}_{i,t} = \beta_0 + \beta_1\ 317\ \text{funding}_{i,t-1} + \gamma X_{i,t-1} + \theta_i\ \text{jurisdiction} + \varepsilon_{i,t}$$

where i indexes the jurisdiction and t indexes the year; X denotes jurisdiction-variant and time-variant confounding variables; *jurisdiction* represents a matrix of jurisdiction-specific dummy variables and time trends; ε represents the residual; and β_0, β_1, and γ represent coefficients estimated through regression.

Dependent Variable: Immunization Outcome

The 2 primary measures of program success used by the Section 317 program are outbreaks of vaccine-preventable disease and vaccination coverage rates. We only used vaccination coverage rates in our model, because outbreaks of vaccine-preventable diseases are rare and are most often caused by random factors that are beyond the control of the Section 317 program, such as disease introduction from a foreign source.[9] The dependent variable was a logit transformation of the proportion of children aged 19 to 35 months who had complete 4:3:1:3:3 vaccination coverage in jurisdiction i during year t.

The 4:3:1:3:3 vaccination series (vaccination coverage) comprises 4 or more doses of any diphtheria and tetanus toxoids and pertussis vaccines, 3 or more doses of any poliovirus vaccine, 1 or more doses of measles-mumps-rubella vaccine or other measles-containing vaccine, 3 or more doses of *Haemophilus influenzae* type b vaccine, and 3 or more doses of hepatitis B vaccine. Vaccination coverage is a composite measure of all childhood vaccines that were recommended by the Advisory Committee on Immunization Practices (ACIP) between 1997 and 2003 for children aged 19 to 35 months, and it represents the routine vaccination schedule of most infants in the United States.[1] We used the 4:3:1:3:3 series as the outcome measure rather than the more recent 4:3:1:3:3:1 series, because all vaccines in the first series were recommended by the ACIP across the entire period of observation and because the 2 series differ only by a single dose of the varicella vaccine.

Key Explanatory Variable: Section 317 Financial Assistance Funding

To ascertain the independent impact of Section 317 program funding on vaccination coverage rates, we used a measure of Section 317 financial assistance funding as the key explanatory variable. The financial assistance component of the Section 317 program accounts for approximately 80% of federal funding for vaccine program operations and activities. In contrast, Section 317 direct assistance funding, which is used primarily for vaccine purchases, accounts for only 20% of federal vaccine purchase funding, with a great deal of additional funding coming from state governments and private insurers. In short, regression models can reasonably be expected to detect an independent impact of financial assistance funding but not direct assistance funding.

We measured Section 317 financial assistance funding as financial assistance allocations in year $t-1$ plus unspent financial assistance funds in year $t-2$ divided by the number of children aged 35 months or younger. We used funding in year $t-1$ because activities during the previous year ($t-1$) were likely to affect the survey measure of coverage rates during the current year (t). We added unspent funds from the end of year $t-2$ because programs were entitled to spend these monies during year $t-1$. We then divided the sum of total available funds by the total number of children aged 35 months or younger in year $t-1$ to reflect the availability of funding in each jurisdiction per child of eligible age to receive vaccinations.

We converted funding amounts in all years to 2003 dollars with the consumer price index for all urban consumers, and we rescaled the funding variable so that a 1-unit increase in the funding variable indicated a $10 increase in per capita funding. Therefore, the coefficient on funding was equal to the proportional change in coverage associated with a $10 increase in funding.

Other Independent Control Variables

We used the following time-varying independent control variables on the basis of previous research[10,11]: percentage of the population who had incomes at or below the federal poverty line, the percentage who had incomes at least 5 times higher than the federal poverty line (5×P), the percentage seeking employment who received some form of unemployment compensation, and the percentage of children aged 15 years or younger who had no health insurance (NOHI). We estimated coverage during the current year (t) as a function of the value during the previous year ($t-1$) for each control variable. Because previous coverage rates were highly correlated with current coverage rates, we also controlled for the previous year's vaccination coverage rate. We used a set of dummy variables to control for jurisdictional fixed effects. To allow for the possibility of different coverage trends across jurisdictions, we included the following control variables: jurisdiction multiplied by time and jurisdiction multiplied by time-squared, where time represented the number of years since 1997.

Model Estimation

We performed a logit transformation (ln[p/1-p]) on the dependent variable to avoid predicting coverage rates less than 0% or greater than 100%, and we weighted each observation to adjust for potential grouped-data bias. Weights were set to $n_{it}\rho_{it}(1-\rho_{it})$ in accordance with the minimum logit χ^2 method, where n_{it} is the number of children aged 18 to 35 months in each jurisdiction and ρ_i is the proportion of those children who were vaccinated.[12] This weighting method weighted observations by the inverse of their contribution to the variance of the error term, such that areas with many immunized children were weighted more heavily. Logit models behave similarly to linear models with respect to fixed-effects adjusters; thus, the coefficients of the variables other than the jurisdictional controls were unaffected by the jurisdictional fixed effects and therefore could be treated as consistent.[13]

In Table 2, we present the logit coefficients and the average marginal effects on all values in the data. The logit coefficients are difficult to interpret because they represented the change in the log-odds of coverage associated with a 1-unit change in 1 of the independent variables. The marginal coefficients are easier to interpret because they indicated the expected change in the proportion of children who had complete coverage associated with a 1-unit change in 1 of the independent variables.

Model Specifications

We estimated vaccination coverage in our fixed-effects model as a function of financial assistance funding, time-variant covariants, jurisdictional impacts, and jurisdiction-specific time effects with the following:

$$(2)\quad \text{Log}\left[(\text{vaccination coverage}_{i,t})/(1-\text{vaccination coverage}_{i,t})\right] = \beta_0+\beta_1\ 317\ \text{Funding}_{i,t-1} + \beta_2\ \text{poverty}_{i,t-1}+\beta_3\ 5\times P_{i,t-1} + \beta_4\ \text{unemployment}_{i,t-1} + \beta_5\ \text{NOHI}_{i,t-1}+\theta_i\ \text{jurisdiction} + \lambda\ \text{jurisdiction}\times\text{time}_{i,t} + \tau\ \text{jurisdiction}\times\text{time}^2_{i,t}+\varepsilon_{i,t}$$

with terms as defined in equation 1 but substituting $\beta_2-\beta_5$ for γ and the named covariates for X and with λ and τ representing the coefficients on the jurisdictional time trends. This fixed-effects model provided an estimate of the average within-jurisdiction effect of Section 317 program funding on immunization coverage rates.

This estimate is a better measure of the causal impact of the program on immunization outcomes than a measure that compares the effect across jurisdictions, because the effect across jurisdictions may be confounded by unmeasured jurisdictional characteristics. For example, if jurisdictions were awarded funding to compensate for low past-coverage rates, estimates that failed to control for fixed effects may have indicated a negative association between funding and vaccination coverage. Fixed-effects models are better for assessing whether changes in funding cause changes in vaccination coverage, because they use only the natural variation within jurisdictions to estimate the impact of changes in funding on vaccination coverage.

Data

We used annual data collected from 1995 to 2003 for all 50 states and 6 cities: Chicago, Ill; Houston, Tex; Philadelphia, Pa; New York, NY: San Antonio, Tex; and Washington, DC (data were missing from 2 observations: New York City in 1995 and Vermont in 2002). We obtained jurisdictional vaccine coverage estimates from the National Immunization Survey,[14] Section 317 program funding data from published sources[1] and from CDC's National Immunization Program, and population data from the Current Population Survey, March Supplement Annual Demographics Survey (1996–2003).[15]

TABLE 1—Analyzed Variables, by Mean, Median, Description, and Data Source: 1996–2003

Variable	Median	Mean ±SD	Description	Source
Vaccination coverage$_t$[a]	73.00	73.18 ±6.13	Percentage of children aged 19 to 35 months who had complete coverage for the 4:3:1:3:3 vaccine series	NIS
Vaccination coverage$_{t-1}$[a]	72.00	71.52 ±5.99	Percentage of children aged 19 to 35 months who had complete coverage for the 4:3:1:3:3 vaccine series in year $t-1$	NIS
Funding per capita per $10 increase$_{t-1}$	1.99	2.49 ±1.71	317 program federal assistance grant allocation + previous year's Section 317 program unspent balance per child aged 35 months or younger (2002 dollars) in year $t-1$	CDC
Poverty$_{t-1}$	12.90	14.72 ±13.20	Percentage of jurisdiction population who lived in households with incomes below 100% of the federal poverty line in year $t-1$	CPS-MS
Income 5 times the federal poverty level or higher$_{t-1}$ (5×P)	24.58	24.54 ±5.69	Percentage of jurisdiction population who lived in households with incomes in excess of 5 times the federal poverty line in year $t-1$	CPS-MS
Unemployment$_{t-1}$	5.51	5.81 ±2.12	Percentage of adult population that received unemployment compensation during the past year in year $t-1$	CPS-MS
No health insurance$_{t-1}$ (NOHI)	7.19	7.63 ±2.22	Percentage of children aged 15 years or younger whose parents reported no health insurance coverage in year $t-1$	CPS-MS

Note. t = current year. NIS = National Immunization Survey; CDC = Centers for Disease Control and Prevention; CPS-MS = Current Population Survey, March Supplement Annual Demographic Survey. t, $t-1$, and $t-2$ index the year.
[a]Vaccine coverage analyzed from 1997–2003.

TABLE 2—Marginal Effects of Independent Variables on Vaccination Coverage: 1997–2003

	Marginal Effect (Logit Coefficient)
Funding per capita per $10 increase$_{t-1}$	0.016* (0.08406)
Poverty$_{t-1}$	–0.001 (–0.00309)
Income 5 times the federal poverty line or higher$_{t-1}$	–0.002 (–0.01009)
Unemployment$_{t-1}$	0.0006* (0.03362)
No health insurance$_{t-1}$	0.004 (0.02341)
Lagged untransformed dependent variable = vaccination coverage$_{t-1}$	–0.004* (–0.02108)
Model Diagnostics	
R^2	0.852
Degrees of freedom	215

Note. Marginal effects are the expected change in the proportion of children who received full vaccination coverage associated with a 1-unit change in the independent variable. Dependent variable = ln(Vaccination Coverage$_{t-1}$/1 – Vaccination Coverage$_{t-1}$); t – 1 = year 1.
*Significant at $P < .01$.

TABLE 3—Marginal Effect of a 1-Unit Increase of Financial Assistance Funding Using Different Model Specifications: 1997–2003

Controls	Marginal Effect of Funding
None	0.007*
Jurisdiction only	0.004*
Jurisdiction, jurisdiction × time	0.010*
Jurisdiction, jurisdiction × time, jurisdiction × time^2 [a]	0.016*
Year excluded	
None[a]	0.016*
1997	0.008
1998	0.017*
1999	0.013*
2000	0.013*
2001	0.017*
2002	0.019*
2003	0.016*

Note. Marginal effects are the expected change in the proportion of children who received full vaccination coverage associated with a 1-unit change in the independent variable.
[a]Base model as shown in Table 2.
*Significant at $P < .01$.

Table 1 shows the means and the standard deviations for all nondummy variables during the years included in the model, which were weighted for the size of each jurisdiction during each year. We calculated the variance inflation factors for each explanatory variable in the model to screen for problematic levels of collinearity. None of the covariates exhibited a variance inflation factor greater than 3.1, which indicated that a regression could tolerate the inclusion of all these variables in the same model.

RESULTS

Our model showed that the effect of financial assistance funding per capita was positive and statistically significant ($P < .01$; Table 2). On average, a $10 increase in funding corresponded with a proportional 1.6% increase in vaccination coverage rates. Increases in unemployment were significantly associated with increases in vaccination coverage, whereas increases in the poverty rate, the uninsured rate, and the percentage of families who had incomes at least 5 times above the poverty line were not. The previous year's vaccination coverage was negatively and significantly associated with current vaccination coverage ($P < .01$).

Model Consistency With Changes in Specification and Data

Our finding of a positive and statistically significant impact of Section 317 financial assistance funding on children's vaccination outcomes was consistent with alternative jurisdictional controls, such as no jurisdictional control, a jurisdictional control with no jurisdiction-specific time effect, and a jurisdiction-specific time effect without a nonlinear component. The effect of Section 317 funding also was positive and significant in a series of models that each omitted 1 year of data, with the exception of the model that omitted 1997 (Table 3).

Model Validity

To test the validity of our interpretation that Section 317 financial assistance funding was causally associated with increases in vaccination coverage rates, we evaluated whether later years of funding also appeared to be associated with coverage during the current year. We estimated 3 alternative versions of model 1, with the first adding financial assistance funding in year t, the second adding financial assistance funding in year $t+1$, and the third including both (each model also controlled for the effect of spending during year $t-1$). In each model, the coefficient on financial assistance funding for year $t-1$ was positive and significant ($P < .01$) and of roughly the same magnitude as in the base model, and the coefficients on financial assistance funding for years t and $t+1$ were small in magnitude and not statistically significant ($P > .65$ in each instance).

DISCUSSION

We found that increases in Section 317 financial assistance funding were positively and significantly associated with increases in vaccination coverage rates. This finding was consistent with a wide range of model specifications, including several alternative specifications of the fixed-effects controls and the removal of individual years of data from the analysis, and is temporally consistent with a causal relationship. Future Section 317 allocations were not associated with current vaccination outcomes, which suggested that the study results do not merely reflect an association between high coverage rates and high funding levels; there also was a causal link in which increases in funding preceded increases in coverage rates. The association between funding and vaccination coverage rates was not readily apparent simply by evaluating descriptive data. During the same time period used in the model, mean vaccination coverage rates increased from 69.9% to 79.5%, and mean per capita financial assistance funding decreased from $52 per capita to $27 per capita (Figure 1).

Increases in the unemployment variable were significantly associated with increases in vaccination coverage rates, whereas changes in the following variables were not: percentage of people who lived at or below the poverty line, percentage or people who had incomes at least 5 times above the poverty line, and percentage of people who were uninsured. The significant positive association between unemployment and vaccination coverage rates could be associated with eligibility criteria for the Vaccines for Children program, which offers more generous reimbursement for children of the unemployed than for children of the employed who may be uninsured or underinsured. The absence of an association between poverty and vaccination coverage rates may indicate that public programs, such as the Section 317 grant program, are succeeding in overcoming socioeconomic barriers to vaccination.

Our study has some data limitations. The funding data consisted of allocations—as opposed to expenditures—and included no information about how funding was allocated within a jurisdiction, the dependent variable did not record the impact of funding allocated to children older than 35 months, and there was only a short panel (7 years) of usable data. However, these data limitations increased the standard error of the regression estimates and thus, made it more difficult to identify a significant effect of financial assistance funding. The fact that the results show a significant association between funding and vaccination coverage rates despite the data limitations underscores the strength of that association.

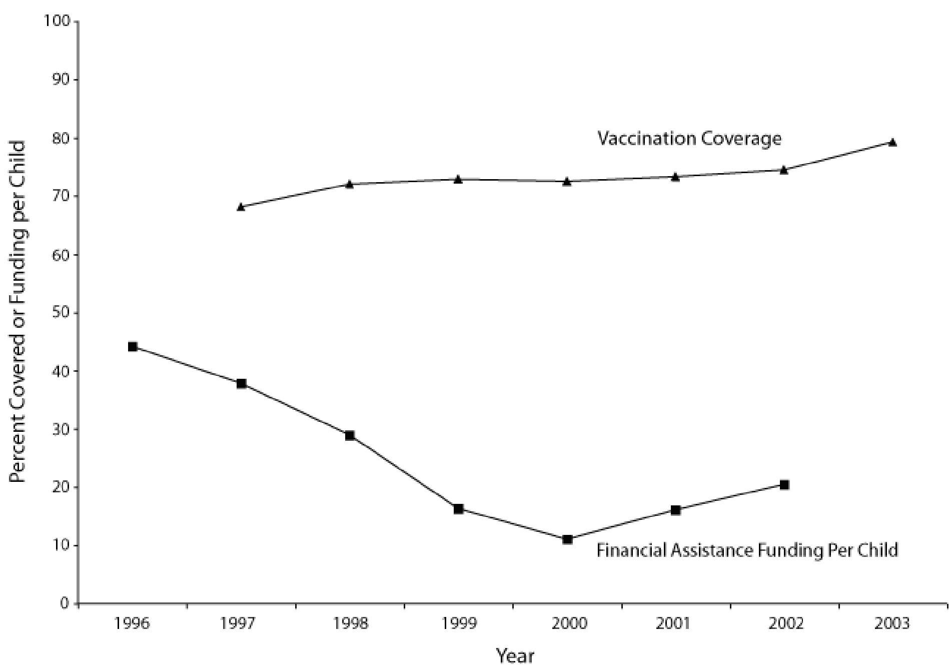

FIGURE 1—Average percentage of children aged 19 to 35 months who had complete vaccination coverage and average financial assistance funding per child: United States, 1996–2003.

CONCLUSIONS

The Section 317 program has been politically vulnerable, particularly in the era of the Office of Management and Budget's Performance Assessment Tool.[16] This tool requires federal programs to empirically show direct associations between their activities and improved program outcomes that are independent of other funding sources. As discussed earlier, this association is difficult to show for the Section 317 program because of the confounding nature of the decentralized vaccination system. We controlled for this confounding in our fixed-effects model and were able to show that each $10 increase to Section 317 financial assistance funding corresponded with a 1.6% increase in vaccination coverage rates between 1997 and 2003.

When this estimated effect is applied to the US child cohort, our model predicts that 240 000 additional children would have achieved full vaccination coverage in 2003 if Section 317 financial assistance funding had remained at 1997 levels. Furthermore, this considerable program impact may be conservative, because the use of the Section 317 financial assistance funding also likely enhances the effectiveness of other vaccination funding, such as monies for financing vaccines, and the model only considered the impact of funding apart from other programs.

Because of current US federal budget constraints and competing priorities for discretionary funding, funding for all public health programs, including the Section 317 program, are at risk. When considering future allocations to the Section 317 program, policymakers should also consider the strong empirical association between financial assistance funding and increased child immunization rates. Funding added to the Section 317 program clearly led to improvements in vaccination coverage rates during the time period we studied. Future reductions to this funding may hinder the capability of the United States to meet its long-term vaccination objectives.[16] ■

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Contributors

D. B. Rein and A. A. Honeycutt designed the study's analytic plan and jointly made most of the research decisions. D. B. Rein developed the data set, conducted the analytic work and wrote the article, with A. A. Honeycutt serving as the primary reviewer and editor. L. Rojas-Smith and J. C. Hersey provided feedback on drafts and obtained funding.

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Human Participant Protection

No protocol approval was needed for this study.

References

1. Institute of Medicine. *Calling the Shots: Immunization Finance Policies and Practices.* Washington, DC: National Academy Press; 2000.

2. Orenstein WA. Testimony on the immunization grant program of the PHS, 1997. Available at: http://www.hhs.gov/asl/testify/t970506a.html. Accessed July 1, 2004.

3. Brink E, Koops G, Brusuelas K, Hicks T. *Immunization Program Operations Manual (IPOM).* Atlanta, Ga: Centers for Disease Control and Prevention, National Immunization Program; 2000.

4. Schmitt HJ, Booy R, Weil-Olivier C, Van Damme P, Cohen R, Peltola H. Child vaccination policies in Europe: a report from the summits of independent European vaccination experts. *Lancet Infect Dis.* 2003;3:103–108.

5. Hinman AR, Orenstein WA, Rodewald L. Financing immunizations in the United States. *Clin Infect Dis.* 2004;15:1440–1446.

6. Johnson KA, Sardell A, Richards B. Federal immunization policy and funding: a history of responding to crises. *Am J Prev Med.* 2000;19:99–112.

7. Fairbrother G, Kuttner H, Miller W, et al. Findings from case studies of state and local immunization programs. *Am J Prev Med.* 2000;19:54–77.

8. Office of Management and Budget. Performance and management assessments. Available at: http://www.whitehouse.gov/omb/budget/fy2004/pma.html. Accessed July 1, 2004.

9. Dayan G, Papania M, Redd S, et al. Epidemiology of measles, United States 2001 to 2003. *MMWR Morb Mortal Wkly Rep.* 2004;53:713–716.

10. Hinman AR, Orenstein WA, Rodewald L. Childhood immunization: laws that work. *J Law Med Ethics.* 2002;30:122–127.

11. Freed GL, Clark SJ, Pathman DE, Schectman R, Serling J. Impact of North Carolina's universal vaccine purchase program by children's insurance status. *Arch Pediatr Adolesc Med.* 1999; 153:748–754.

12. Maddala GS. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge, UK: Cambridge University Press; 1999.

13. Greene W. Fixed and random effects in nonlinear models. Department of Economics, NYU Stern School of Business. Available at: http://pages.stern.nyu.edu/~wgreene/. Accessed July 1, 2005.

14. Centers for Disease Control and Prevention, National Immunization Survey. Immunization coverage in the US: estimated vaccination coverage with individual vaccines and selected vaccination series among children 19–35 months of age by state and immunization action plan area. Available at: http://www.cdc.gov/nis/datafiles.htm. Accessed July 1, 2005.

15. *Current Population Survey, Annual Demographics File* (annual computer files from 1996 to 2003). Washington, DC: US Dept of Commerce, Bureau of the Census.

16. US Department of Health and Human Services. *Healthy People 2010: Understanding and Improving Health.* 2nd ed. Washington, DC: US Government Printing Office; 2000.