Appendix E

Methodology for Statistical Analyses

Data

Based on prior research and data availability, we analyzed 4 service delivery outputs and 11 health status outcomes while controlling for agency type, several demographic factors, expenditures per capita, FTEs per 1,000 population, and availability of selected services. Brief descriptions and data sources of all variables are provided below.

Output Measure	Description	Data Source	Years
WIC Prenatal Services	Percentage of Medicaid deliveries where prenatal WIC assistance was received	NCDHHS, Nutrition Services Branch	2005–2010
HealthCheck Visits	Percentage of Medicaid-enrolled children who received at least one HealthCheck screening annually	NCDHHS, Division of Medical Assistance[a]	2005–2009
Lead Screening Tests[ø]	Percentage of Medicaid-eligible children, ages birth to 2, who received direct blood lead screening tests	NCDHHS, Environmental Health Section	2005–2010
Immunization Compliance[ø]	Percentage of 2-year-old children, registered with the state health system, who have received age-appropriate immunizations[b]	NCDHHS, Women and Children's Health Division	2005–2010

Service Delivery Outputs
[a] HealthCheck Visits for FY2005-2009 were provided by the agency listed. FY2010 rates were calculated using data from the prior two years.

[b] These are not immunization coverage rates. Children must be registered with the North Carolina Immunization Registry (NCIR). If not, the child will not be reflected in the LHD compliance rate, even if the child received immunizations at the LHD or elsewhere.

[ø] Denotes that the variable was transformed, in all regression equations. For more details, please refer to the section *Testing,* in this appendix.

Health Status Outcomes

Outcome Measure	Description	Data Source	Year
Chlamydia Rate[‡]	Number of Chlamydia cases per 100,000 members of the population	NCDHHS, Epidemiology Section	2005–2010
Gonorrhea Rate[§]	Number of Gonorrhea cases per 100,000 members of the population	NCDHHS, Epidemiology Section	2005–2010
HIV-Disease Rate[§]	Number of HIV diagnoses per 100,000 members of the population[a]	NCDHHS, Epidemiology Section, Communicable Disease Branch	2005–2010
HIV-Death Rate[§]	Number of HIV-related deaths per 100,000 members of the population	NCDHHS, State Center for Health Statistics	2005–2010
Syphilis Rate[§]	Number of syphilis cases per 100,000 members of the population	NCDHHS, State Center for Health Statistics	2005–2010
Tuberculosis (TB) Rate[§]	Number of tuberculosis cases per 100,000 members of the population	NCDHHS, State Center for Health Statistics	2005–2010
Positive Lead Screening Results[§]	Percentage of tested children, ages 1 and 2, with elevated blood lead levels ($\geq$10)	NCDHHS, Environmental Health Section	2005–2010
Infant Mortality Rate[§]	Number of deaths of infants, under age 1, per 1,000 live births	NCDHHS, State Center for Health Statistics	2005–2010
Smoking[Ø]	Percentage of adults who currently smoke	County Health Rankings	2009[b]
Obesity	Percentage of the population estimated to be obese	County Health Rankings	2008[c]
Teenage Pregnancy Rate	The number of pregnancies per 1,000 women, between the ages of 15 and 19	NCDHHS, State Center for Health Statistics	2005–2010

[a] HIV Disease includes all newly diagnosed HIV infected individuals by the date of first diagnosis, regardless of status (HIV or AIDS).
[b] Aggregate smoking percentage for 2002–2009.
[c] Single-year obesity percentage for 2008. These data were matched against 2007 data for other variables, in a given model.
[Ø, §, ‡] Denotes that the variable was transformed, in all regression equations. For more details, please refer to the section *Testing,* in this appendix.

Demographic and LHD Capacity Variables

Category	Variable and Description	Data Source	Year
LHD Model	1. County Health Department (n = 75) 2. District Health Department (n = 6) 3. Other Models (n = 4): Comprising Consolidated Human Services Agencies (n=2), Public Health Authority (n=1), and Hospital Authority (n=1). These models were grouped together because there are simply too few of these agency types in existence in North Carolina to render results that are generalizable or applicable in similar settings.		
Race	1. Percentage of population identified as White[‡] 2. Percentage of population identified as Black[‡] 3. Percentage of population identified as Hispanic[‡] 4. Percentage of population not identified by the above categories[‡]	Census Bureau Intercensal Estimates of Resident Population for Counties	2005–2010
Percentage of the Uninsured Population	Proportion of population ages 0 to 64 that do not have health insurance	Prepared by the North Carolina Institute of Medicine and the Cecil G Sheps Center for Health Services Research, University of North Carolina at Chapel Hill	2007-–2009
Population Size[‡]	100% count of resident population of the LHD service area	Census Bureau Intercensal Estimates of Resident Population for Counties	2005–2010
Population Density[‡]	Number of people per square mile in LHD service area	Census Bureau Intercensal Estimates of Resident Population for Counties, NC Office of State Budget and Management	2005–2010
Percentage unemployed	The percentage of the labor force that is unemployed	Bureau of Labor Statistics Local Area Unemployment Statistics	2005–2010
Median Household Income[‡]	Median household income is the middle income of all households—half of the household members earn more and half earn less. Household income is the total income of all income earners over age 15 living in a household. Data for districts represents a weighted average	Census Small Area Income and Poverty Estimates	2005–2010

	of the component counties' rates.		
Financial Resources	1. Local expenditures per capita[‡] 2. State and federal expenditures per capita[‡]	NC DHHS Revenue Source Book	2006–2010
Human Resources	Number of full-time equivalent positions (FTEs) per capita[‡]	NC LHD Survey	2005, 2007, 2009, and 2011
Services	1. Percentage of the 93 consistently tracked services offered by the LHD (See section *Percentage of 93 Tracked Services,* in this appendix, for details) 2. *Specific services related to each output or outcome (See section Services Controlled for in Statistical Analyses, in this appendix, for details)*	NC LHD Survey	2005, 2007, 2009, and 2011

[‡] Indicates that the variable was transformed, in all model equations. Refer to the section *Testing*, in this appendix, for the specific functional form.

Methodology

Regression Models

A Random Effects (RE) model was used due to model implementation concerns. Jurisdictions may have implemented LHD organizations model types in different ways, which questioned the assumption of common effect sizes. Under a RE model, we estimated the mean distribution of effects among different LHDs. This allowed us to generalize the results more widely. However, for smoking and obesity outcomes, we used Ordinary Least Squares Regression (OLS) models, because only one year of data for those outcomes was available.

Testing

Statistical tests were conducted to assess multicollinearity concerns and to determine the most appropriate functional forms and model specification.

- Multicollinearity tests were conducted, which prompted elimination of many service program measures.
- Examination of the normality of the data distributions prompted logarithmic transformation of most variables. Logarithmic transformations took three forms and are denoted by the following symbols:

  ‡ = log(variable), traditional logarithmic form

  § = log(variable +1), applied when the variable's minimum value was zero.

  Ø = log(constant – variable), applied when the variable's skew was less than negative one. The constant was equal to the variable's maximum value plus one.

- To correct for evidence of heteroskedasticity and autocorrelation, the RE models were clustered by LHD. The Generalized Least Squares estimator, used in RE models, provided an efficient estimator because the new error term becomes serially uncorrelated. For the health status

outcomes in the OLS models, we only applied robust standard errors, as serial correlation was not a concern.

Model Equations

Using two RE models, and an OLS model for the single year outcomes, we tested the effects of LHD model on service delivery outputs and health status outcomes, while controlling for demographic factors, expenditures per capita, FTEs per capita, and availability of selected services.

In Model 1, we tested the relationship between LHD model and outputs, controlling for demographics, organizational capacity, and selected services. In Model 2, we tested the relationship between LHD model and outcomes, controlling for demographics, expenditures per capita, FTEs per capita, selected services, and outputs. The regression equations for each model are as follows:

Model 1: Relationship between LHD model and outputs, controlling for demographics, organizational capacity, and selected services.

$$Y(Outputs) = a_i + \beta(LHD\ Model) + \gamma(Demographics) + \theta(Capacity) + \varepsilon_{it}$$

Model 2: Relationship between LHD model and outcomes, controlling for demographics, expenditures per capita, FTEs per capita, selected services, and outputs.

Model 2a: Random Effects Model
$$Y(Outcome) = a_i + \beta(LHD\ Model) + \gamma(Demographics) + \theta(Capacity) + \tau(Targeted\ Services + \varphi(Outputs) + \varepsilon_{it}$$

Model 2b: OLS Model
$$Y(Outcome) = a + \beta(LHD\ Model) + \gamma(Demographics) + \theta(Capacity) + \tau(Targeted\ Services + \varphi(Outputs) + \varepsilon$$

Interpreting Regression Outputs

Reading Outcomes: Logged and Unlogged Variables

Often, variables will undergo a transformation (e.g., log, squared, cubic, etc.) to provide more normalized data and residual distributions. While these transformations do not alter the data, additional steps are required when reading regression coefficients. Many of the dependent and independent variables in this study were logged. Therefore, outcomes should be interpreted as follows:

Dependent Variable (Y)	Independent Variable (X)	Interpretation of Coefficient (C)
Not logged	Not logged	On average, a 1 unit change in X will produce a C unit change in Y
Logged	Not logged	On average, a 1 unit change in X will produce a [(exp(C)-1]*100% change in Y
Not Logged	Logged	On average, a 1% change in X will produce a C/100 unit change in Y
Logged	Logged	On average, a 1% change in X will produce a C% change in Y

For example, Percentage Uninsured (unlogged, independent variable) had a statistically significant effect on Chlamydia Rate (logged, dependent variable) with a coefficient of 0.14. Therefore, if the Percentage Uninsured in an LHD's service area increased by 1, we would expect the Chlamydia Rate to go up by an average of 15.03% (*not* to be confused with 15.03 percentage points—see next section).

Changes in Percentage vs. Percentage-Points
A percentage describes the relative change of a number, expressed as a ratio. For example, a price change from $1,000 to $1,500 represents a 0.5 increase in the price ((New Price – Original Price) /Original Price). This $0.50 increase, expressed as a percent, equals 50%.

A percentage point change only describes the difference between two percentages. It does not describe the change to the original value. For example, change from 10% to 12% is a two percentage-point change (12% - 10% = 2 percentage points).

Study Limitations
There are two primary limitations to this study. First, most variables did not have data for the entire five-year period studied. We performed moving average calculations, when possible, for missing data. However some data were missing because of the periodicity of the collection methods. For example, the LHD survey is collected biannually and only provided up to three years of results whenever services variables were included in a regression model. Additionally, only one year of data was available for smoking and obesity outcome measures, so those results may not be consistent over time.

Second, because the LHD Survey data is self-reported, there are concerns about construct validity. For example, service programs were included even though service program definitions were absent from the survey instrument. Some measures were not included because we had substantial concerns about the consistency of responses within an LHD, between survey periods, and between different LHDs. In these cases, we lost data that could have been useful output and outcome predictors.

Percentage of 93 Tracked Public Health Activities
The percentage of 93 activities or services offered by each local health department is based on FY2005–FY2011 data from the Local Health Department Survey, which the North Carolina Department of Health and Human Services administers biennially. This measure was used for the in-depth statistical analysis only, requiring that each fiscal year have the same denominator. The survey instrument, which provided the data for this measure, remained constant from FY2005 to FY2009 but changed significantly in FY2011. In FY2011, several service categories expanded, increasing the number of tracked services from 95 to 127. To ensure comparable data, we eliminated services that were not included in every survey and, when possible, reconciled services that shared similar descriptions and results across the years. Ultimately, we examined whether LHDs offered 93 services that were consistently tracked from FY2005 to FY2011. It is worth noting that many LHDs offer more services than the survey captured or we included.

Registration of Vital Events
      1.   Registration of Vital Events
Epidemic Investigations

2. Risk Assessment
3. Pesticide Poisoning

Health Assessment
4. Comprehensive Community Health Assessment
5. Behavioral Risk Assessment
6. Morbidity Data
7. Reportable Disease
8. Vital Records and Statistics
9. Chronic Disease Surveillance
10. Communicable Disease Surveillance
11. Bioterrorism and Other Emergency Preparedness and Response Planning and Assessment

Policy Development Functions and Services
12. Health Code Development and Enforcement
13. Health Planning

Health Assurance
14. Health Education
15. Child Health
16. Prenatal Care

Community Health Education
17. Community Health Education

Interpretation, Spoken Language
18. Interpretation, Spoken Language

Laboratory Services
19. Laboratory Services

Pharmacy Services
20. Public Health Nurse Pharmacy Dispensing
21. Other Pharmacy Services

School Nursing Services
22. School Nursing Services

Restaurant/Lodging/Institutions Sanitation and Inspections
23. Restaurant/Lodging/Institutions Sanitation and Inspections

On-Site Sewage and Wastewater Disposal
24. On-Site Sewage and Wastewater Disposal

Water Sanitation and Safety
25. Water Sanitation and Safety (Measured as Public Water Supply in 2005 survey)
26. Private Water Supply
27. Milk Sanitation
28. Shellfish Sanitation
29. Public Swimming Pool

Bedding Control
30. Bedding Control

Pest Management
31. Mosquito
32. Rodent
33. Tick

Lead Abatement
34. Lead Abatement

Primary Care

35. Primary Care—Adult
36. Primary Care—Pediatric

Maternal Health
37. Prenatal and Postpartum Care
38. Maternity Care Coordination
39. SIDS Counseling
40. WIC Services—Mother

Family Planning
41. Pre-conceptional Counseling
42. Contraceptive Care
43. Fertility Services
44. Pregnancy Prevention—Adolescent

Child Health
45. Well-Child Services
46. Genetic Services
47. Services to Developmentally Disabled Children
48. Child Service Coordination
49. Adolescent Health Services
50. School Health Services
51. Lead Poisoning Services
52. WIC Services—Children
53. Immunizations
54. Newborn Home Visiting Services
55. Behavioral Health Services
56. Children with Special Health Care Needs Services

Chronic Disease Control
Early Detection and Referral
57. Kidney Disease
58. Hypertension
59. Cancer
60. Diabetes
61. Cholesterol
62. Arthritis
63. Glaucoma
64. Epilepsy
Patient Education
65. Kidney Disease
66. Hypertension
67. Cancer
68. Diabetes
69. Cholesterol
70. Arthritis
71. Glaucoma
72. Epilepsy

Chronic Disease Monitoring and Treatment
73. Chronic Disease Monitoring and Treatment

Home Health Services
74. Home Health Services

Health Promotion and Risk Reduction

      75. Nutrition Counseling

      76. Injury Control

      77. Tobacco Cessation

Communicable Disease Control

      78. Tuberculosis Control

      79. Acute Communicable Disease Control

      80. STD Control Training/Education

      81. STD Control Screening

      82. AIDS/HIV Screening

      83. Hepatitis A and B

      84. Rabies Control

Dental Health

      85. Dental Health Education

      86. Topical Fluoride Application

      87. Sealant Application

      88. Dental Screening and Referral

      89. Dental Treatment

      90. Community Fluoridation

      91. "Into the Mouths of Babes" Dental Preventative Services

Other Personal Health

      92. Migrant Health

      93. Refugee Health

Services Controlled for in Statistical Analyses

The services below are based on 93 consistently tracked services, from the LHD Staff and Services Summary Survey for FY2005, FY2007, and FY2009. For each health output or outcome, we controlled for the bulleted delivery of services. The goal was to control for services that were directly tied to the output or outcome, based on contractual obligations, or that may contribute to an indicator.
Please note that some services, which met the aforementioned goal, were excluded because of high collinearity with other services within an individual regression.

A. Outputs—Health Service Delivery Indicators

Percentage of Medicaid deliveries where prenatal WIC assistance was received

- WIC Services—Mother
- Prenatal and Postpartum Care
- Health Assurance—Prenatal Care

Percentage of Medicaid-eligible children who had at least one HealthCheck visit

- Primary Care Pediatrics
- Child Health—Well-Child Services
- Child Services Coordination

Percentage of Medicaid-eligible children, ages birth to 2, who received direct blood lead screening tests

- Lead Poisoning Services
- Lead Abatement
- Child Health—Well-Child Services
- Primary Care Pediatrics

Percentage of children, age 2, registered with the state health system, who have received age-appropriate immunizations
- Immunizations
- Primary Care Pediatrics
- Child Health—Well-Child Services
- Child Services Coordination

B. Outcomes—Health Status Indicators

Chlamydia rate per 100,000 population
- STD Training/Education
- STD Screening
- Primary Care—Adult
- Comprehensive Community Health Assessment
- Behavioral Risk Assessment
- Community Health Education
- Adolescent Health Services

Gonorrhea rate per 100,000 population
- Same services as the Chlamydia indicator

HIV-disease rate per 100,000 population
- Same services as the Chlamydia indicator

HIV-disease deaths per 100,000 population
- Same services as the Chlamydia indicator

Primary and Secondary Syphilis rate per 100,000 population
- Same services as the Chlamydia indicator

Tuberculosis rate per 100,000 population
- Acute Communicable Disease Control
- Communicable Disease Surveillance
- Community Health Education
- Primary Care—Adult
- Immunizations
- Primary Care Pediatrics

Percentage of children tested, ages 1–2, with elevated blood lead levels
- Lead Poisoning Services
- Lead Abatement
- Child Health—Well-Child Services
- Primary Care Pediatrics

Infant deaths per 1,000 live births

- SIDS Counseling
- Health Assurance—Health Education
- Health Assurance—Child Health
- New Born Home Visits
- Primary Care Pediatrics
- Prenatal & Postpartum Care
- Child Health—Well-Child Services
- Health Assurance—Prenatal Care

Percentage of adults who currently smoke
- Tobacco Cessation
- Primary Care—Adult

Percentage of the population estimated to be obese
- Primary Care—Adult
- Community Health Education
- Nutrition Counseling
- Comprehensive Community Health Assessment
- Behavioral Risk Assessment

Adolescent pregnancy rate among females ages 15 to 19
- Pregnancy Prevention—Adolescent
- Health Services