Building the Evidence for Decision-Making: The Relationship Between Local Public Health Capacity and Community Mortality

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Objectives. We examined associations between local health department (LHD) spending, staffing, and services and community health outcomes in North Carolina.

Methods. We analyzed LHD investments and community mortality in North Carolina from 2005 through 2010. We obtained LHD spending, staffing, and services data from the National Association of City and County Health Officials 2005 and 2008 profile surveys. Five mortality rates were constructed using Centers for Disease Control and Prevention mortality files, North Carolina vital statistics data, and census data for LHD service jurisdictions: heart disease, cancer, diabetes, pneumonia and influenza, and infant mortality.

Results. Spending, staffing, and services varied widely by location and over time in the 85 North Carolina LHDs. A 1% increase in full-time-equivalent staffing (per 1000 population) was associated with decrease of 0.01 infant deaths per 1000 live births ($P < .05$). Provision of women and children's services was associated with a reduction of 1 to 2 infant deaths per 1000 live births ($P < .05$).

Conclusions. Our findings, in the context of other studies, provide support for investment in local public health services to improve community health. (*Am J Public Health.* 2015;105:S211–S216. doi:10.2105/AJPH.2014.302500)

The length and severity of the recent economic recession created challenging conditions for local health departments (LHDs). Faced with reduced financial resources, many LHDs eliminated staff and cut or reduced services. Nearly half (48%) of LHDs reduced or eliminated services in 2008.[1] By 2012, the combined workforce loss in the United States since the start of the recession in 2008 was estimated at almost 44 000.[2] The common mantra of local health directors in the past has been that they are often asked to do more with less. Now, they have found themselves trying to determine how to do less with less—a task made more complicated by a limited evidence base to inform decision-making. In a national survey of local health officials, the effectiveness of a service was the factor listed by most as being influential in their decisions about resource allocation.[3] Yet, evidence of the impact of public health services is not clear. Similarly, data on capacity measures such as spending, staffing, or services are sparse, and systematic evaluation is challenging.[4] This challenge is especially true at the local level at which many funding and programmatic decisions are made.

The national public health systems and services research agenda has identified the need for evidence demonstrating which investments and strategies have the largest effect on community health outcomes.[5] The Consensus Statement on Quality in Public Health has stated that public health practices should be efficient, which includes understanding the costs and outcomes associated with programs.[6] The field of public health systems and services research has also recognized that investments in data and methods are needed.[7] Our study was conducted in this context. We examined the association between investments in local public health and community health outcomes in North Carolina, with the aim of contributing to the evidence base linking public health services with community outcomes.

Our work builds on previous studies of the associations between community outcomes and public health capacity (usually measured in terms of spending, staffing, and services) and processes (usually measured through performance of essential services or community outcomes). Our analytic approach was guided by the conceptual model proposed by Meyer et al.[4] This framework illustrates that public health outcomes are influenced by performance and services provided by public health systems, which are in turn influenced by the organizational capacity of the public health systems. Using this model, funding is categorized as an economic resource and staffing as a human resource, which are 2 of the types of organizational resources that influence the capacity of LHDs to perform services. This model depicts a temporal pathway from capacity to services to outcome, but it does not identify specific measures of the model components or the interrelationships between indicators of capacity (such as funding and staffing).

Literature in the field of public health systems and services research has consistently measured the association between community outcomes with either capacity measures or processes measures, but seldom with both. Mays and Smith[8] examined associations between levels of local public health spending and preventable mortality over a 13-year period. Spending was significantly associated with reductions in 4 outcomes—infant mortality and deaths from cancer, heart disease, and diabetes—but not in influenza deaths or all-cause mortality. Erwin et al.[9] examined changes in local resources and staffing, aggregated to the state level, from 1995 through 2005, as predictors of community health outcomes. They found reductions in infectious disease morbidity associated with higher local health spending

and reductions in cardiovascular mortality associated with greater full-time-equivalent (FTE) staffing. They found no associations between spending or FTEs for the outcomes of smoking, obesity, cancer deaths, infant mortality, and years of potential life lost. In a similar study over a longer time, researchers reported associations between LHD expenditures and infant mortality and years of potential life lost.[10]

A 2008 literature review identified 23 peer-reviewed articles on LHD performance.[11] LHD characteristics associated with higher performance included greater funding, more staffing, and a larger population served. Two landmark studies have examined public health system performance using indicators based on performance of the 10 essential services.[12,13] These studies observed associations between higher public health system performance and higher levels of funding. However, a later study showed significant associations between higher performance and other metrics, including larger size of the population served, presence of boards of health, and educational background of the top officer in the LHD.[14] Direct federal per capita spending was significantly associated with only 1 of 10 essential services. Staffing was not associated with performance. In a recent study looking at the association between outcomes and spending, Bekemeier et al.[15] observed an association between LHD investments in maternal and child health services and reduced rates of low birth weight babies.

A few North Carolina–specific studies have examined the capacity indicators as predictors of LHD performance. Hajat et al.[16] measured performance of 9 service categories. They observed workforce characteristics, such as staff education, certification, and experience, were important predictors for most services. Staffing, measured as FTEs, and spending were significantly associated with only 1 service area each. Porterfield et al.[17] examined LHD diabetes prevention and control activities and characteristics associated with performance. Health department FTEs, expenditures and accreditation status, and diabetes-specific external funding were significantly associated with diabetes prevention and control performance.

Although previous studies[8–10,18] have shown some support for the hypothesis that investments in public health improve LHD performance and community health, results have been inconsistent. This may be, in part, a result of conceptual and methodological differences in the studies. The use of different measures for capacity, services, and outcomes; differential emphasis on specific parts of the temporal pathway; and modeling strategies likely contribute to the lack of consistency in study findings related to public health investments and outcomes. In an effort to enhance understanding of the relationships among capacity, services, and outcomes, we incorporated multiple constructs to explore the potential pathways by which capacity and services may influence outcomes.

METHODS

Our retrospective study examined the association of North Carolina LHD investments with community outcomes over the time period from 2005 to 2010. Specifically, we were interested in the effects of changes in spending related to the economic recession; thus, we grouped data into time periods before and after the 2008 economic recession.

We obtained LHD spending, staffing, and services data from the National Association of City and County Health Officials' 2005 and 2008 National Profile of Local Health Departments survey data.[19] Spending was analyzed using a per capita expenditure measure constructed from the total reported LHD expenditures and county or service region population. We created a similar measure for staffing by using the reported number of FTEs per 1000 jurisdictional population. Services provided by LHDs were collapsed into 6 categories used in previous published research: clinical preventive services, medical treatment, specialty care services, population-based services, regulatory and licensing services, and environmental services.[18] We assessed the proportion of individual services in each of the 6 categories that were provided or contracted for by the LHD. In addition, we examined selected individual services with selected outcomes to further understand potential mechanisms for observed relationships.

We obtained mortality data from Centers for Disease Control and Prevention compressed mortality files.[20] Four cause-specific and age-adjusted mortality rates (per 100 000 population) were created: heart disease, diabetes, cancer, and pneumonia and influenza. In addition, we also examined infant mortality, using de-identified North Carolina vital statistics data available from the Odum Institute at the University of North Carolina.[21] We calculated the infant mortality rate as the number of deaths for children younger than age 1 per 1000 live births. All rates were calculated separately for 2 time periods: 2005 to 2007 and 2008 to 2010.

We included community characteristics as control variables in regression models for explaining variations in community health outcome. These variables were identified from previous literature[8] and were checked against our conceptual framework. Specifically, we included the following county-level variables from the Area Resource File: demographic composition in the LHD jurisdictional areas (percentage of females, percentage of the population aged 65 years and older, percentage of non-White people, percentage of non-English speakers), socioeconomic characteristics (unemployment rate, percentage of college graduates, percentage of uninsured people, and percentage of people in poverty), health care resources (number of physicians per 100 000 population, public health clinics per 10 000 population, and hospital beds per 100 000 population), total population, and urban–rural area indicator. We used the same control variable for all models except infant mortality outcome. In the regression models concerning infant mortality, we replaced the percentage of people aged 65 years and older with total births. We did not include presence of a board of health, found to be important in previous studies,[12,14] because all North Carolina LHDs had boards of health during the study period.

We defined all the outcome measures and control variables at the LHD level. Among the 85 LHDs that represent 100 counties in North Carolina, 6 (Albemarle, Appalachian, Granville/Vance, Martin/Tyrell/Washington, Rutherford/Polk/McDowell, and Toe River) have jurisdictional area across multiple counties. To obtain LHD-level measures for these multiple-county LHDs, we first identified the counties in each jurisdiction area and computed the measures using data from all the counties combined for each LHD. For example, we selected

mortality data from the 3 counties in the Appalachian LHD and obtained the total age-adjusted rate from the 3 counties. Similarly, to compute the percentage of females in the Appalachian LHD, we summed the number of females and divided by the total population of all 3 counties.

We conducted analyses to answer 3 research questions: (1) whether decreased local public health spending was associated with worse mortality, (2) whether decreased LHD staffing was associated with worse mortality, and (3) whether decreased services were associated with worse mortality. Each LHD had data from 2 time points. Within such temporally structured data, the measures for the same LHD at both time points were expected to be more similar than the measures across different LHDs. We used multilevel models to account for this correlated data structure, such that the data were modeled in 2 levels to incorporate each distinct time point.[22] In addition, we used random intercepts for LHDs in the analyses to allow the mean effect of each LHD to vary instead of forcing them to have the same single intercept as in traditional regression models. This 2-level random-intercept model decomposes the variations into 2 levels, with level 2 variation across LHDs and level 1 variation between time points within an LHD. This approach also made it possible to estimate the effects at different levels. We used directed acyclic graphs[23] to identify the model construction and confounding variables for each model on the basis of our conceptual model and available variables. These graphs are useful in describing the relationship among the 3 key independent variables and mortality outcome. Guided by the directed acyclic graphs, we identified different sets of confounding variables for each model depending on the research question and exposure of interest. For the first research question, we controlled for community factors; for the second research question, we controlled for spending and community factors; and for the third research question, we controlled for spending, staffing, and community factors. In addition to these 3 sets of models, we also ran models to test whether the spending was associated with staffing and services while controlling for community factors. We conducted all statistical analyses in SAS software (version 9.3; SAS Institute, Inc.; Cary, NC).

RESULTS

We observed differences in LHD spending, staffing and services, from community to community and over time. We also identified associations between staffing and services for one of the mortality outcomes examined. Further details of these findings are described below.

Variation in Spending, Staffing, and Services Between 2005 and 2008

Of 85 LHDs, 82 responded to the National Association of City and County Health Officials profile survey in 2005 and 83 responded in 2008 (Table 1). Spending in North Carolina LHDs increased between 2005 and 2008, from $74 per capita to $87 per capita (range = $21.20–$74.50). Although spending increased on average, overall level of staffing in LHDs decreased from an average of 110 FTEs in 2005 to 107 FTEs in 2008. The aggregate figures mask local experience of the economic recession; 10 LHDs experienced a decrease in the amount of spending from 2005 to 2008 and 37 LHDs experienced a decrease in staffing from 2005 to 2008.[19]

The extent of service provision by North Carolina LHDs varied depending on category of service. Clinical preventive services were the most extensively provided category of services, with LHDs providing or contracting for nearly all (90%) of the potential services in this category. Specialty care services were the least likely to be offered, with LHDs providing on average only 30% of the potential services in this category. The overall level of services provided by LHDs changed very little from 2005 to 2008. For individual service items, we found little change over time in most services except obstetric care: 18 LHDs stopped providing the service and 9 LHDs started providing the service in 2008.[19]

Overall, the average age-adjusted mortality rates for heart disease, cancer, diabetes, pneumonia and influenza, and infant mortality fell in

TABLE 1—Characteristics of Local Health Departments and Populations: North Carolina, 2005 and 2008

Characteristic	2005 (n = 82), Mean (SD)	2008 (n = 83), Mean (SD)
Total per capita spending, $	74.5 (36.7)	87.6 (37.5)
Total FTE	109.7 (99.0)	106.7 (96.7)
Services performed,[a] %		
Clinical preventive services	90.2 (15.6)	91.5 (11.9)
Medical treatment services	60.7 (15.9)	59.5 (16.3)
Specialty care services	30.1 (25.5)	27.3 (23.9)
Population-based activities	58.4 (21.3)	62.1 (21.0)
Regulatory and licensing activities	61.0 (18.9)	61.8 (15.0)
Environmental health activities	30.5 (19.0)	31.2 (19.7)
Maternal and child health services	84.6 (20.2)	86.2 (12.9)
Mortality rate[b]		
Heart	214 (35)	195 (33)
Diabetes	27 (10)	24 (9)
Cancer	195 (33)	183 (17)
Influenza or pneumonia	22 (9)	20 (7)
Infant	9 (3)	8 (3)

Note. FTE = full-time equivalent.
Source. National Association of City and County Health Officials,[19] Centers for Disease Control and Prevention,[20] and Odum Institute at the University of North Carolina.[21]
[a]Percentage of services performed or contracted for by local health department.
[b]All mortality rates except infant mortality rate were age adjusted by 2000 Census population and measured per 100 000 population. Infant mortality rate was measured at per 1000 live births. Mortality rates were calculated from 2005–2007 (for 2005) and 2008–2010 (for 2008).

TABLE 2—Coefficient Estimate of Per-Capita Spending (Logged) on Full-Time-Equivalent Staff and Services: National Association of City and County Health Officials Profile Surveys, North Carolina, 2005 and 2008

Staffing and Services	Coefficient	*P*
FTE staff	0.384	<.001
Services		
Clinical preventive services	−2.612	.42
Medical treatment services	14.070	<.001
Specialty care services	12.003	.049
Population-based activities	6.853	.19
Regulatory and licensing activities	−4.991	.203
Environmental health activities	−9.207	.072

Note. FTE = full-time equivalent per 1000 population. We obtained the coefficient estimate from each model, in which we controlled for year, public clinics per 10 000 population, percentage female, unemployment rate, percentage non-White, percentage of population aged 65 years or older, total population, percentage of college graduates, percentage of non-English speakers, physicians per 100 000 population, hospital beds per 100 000 population, percentage of population living in poverty, percentage uninsured, and urban indicator.

the jurisdictions between 2005 and 2008 (Table 1). We observed this reduction in more than two thirds of the LHDs. The burden of mortality, however, varied by location, with higher infant mortality observed in eastern areas of North Carolina.[21]

Association of Outcomes With Spending, Staffing, and Services

We used directed acyclic graphs to guide our multivariate modeling strategy and appropriately control for community factors as well as required model constructs (i.e., specific capacity or process measures). After specifying the model, we found that increases in spending were associated with statistically significant increases in FTE: on average, a 1% increase in per capita spending was associated with a 0.4% increase in FTE per 1000 population (Table 2). Increases in capacity as measured by spending were also associated with increased provision of 2 categories of services: medical treatment services and specialty care services. A 1% increase in per capita spending was associated with a more than 10% increase in these services.

We did not find associations between changes in spending and mortality (Table 3) after controlling for community factors. Changes in FTEs, however, were significantly associated with infant mortality—an increase in LHD staffing was significantly associated with lower infant mortality ($P<.05$; Table 3), controlling for community factors and spending. More specifically, a 1% increase in FTE per 1000 population was associated with a reduction of 0.01 infant deaths per 1000 live births, after controlling for community factors and spending. A greater level of medical care treatment provided by LHDs was associated with reduced infant mortality ($P<.05$) when community factors, LHD spending, and staffing were held constant. We observed no other associations between staffing, services, and mortality.

Further analyses examining the effect of changes in the provision of specific types of services expected to affect infant mortality revealed 2 significant associations between an increase in the provision of services and a reduction in infant mortality (Table 4) after controlling for community factors and LHD spending and staffing. Provision of women and children's services was associated with a decrease in infant mortality rates ($P<.05$). Specifically, provision of prenatal care and obstetrical services was associated with 1 to 2 fewer infant deaths per 1000 live births.

DISCUSSION

We observed reductions in infant mortality associated with increased staffing and provision of prenatal and obstetric care in North Carolina LHDs. Our findings are consistent with the implications of previous studies, though we found some differences.[8,10]

In our study, we did not see previously observed associations between increased LHD spending and improved outcomes for 3 causes of mortality (heart disease, diabetes, cancer).[8,10] There are several potential explanations for the differences between our findings and those of previous researchers. First, our study covered a much smaller population and a shorter time period than previous studies. Second, spending per se is not expected to have a direct causal effect on health outcomes. Rather, other aspects of capacity, such as staffing and programs enabled through LHD spending, are expected to improve outcomes. Our results did confirm associations between increases in the intermediary variables of staffing and services on improved infant mortality. Infant mortality is substantively different from chronic mortality outcomes. Heart disease, diabetes, and cancer are diseases with long latency periods. Any changes in spending would not be

TABLE 3—Coefficient Estimate of Local Health Department Spending, Staffing, and Medical Treatment Services on Mortality: North Carolina, 2005 and 2008

Cause of Mortality	Spending Effect on Mortality	Staffing Effect on Mortality	Medical Treatment Services Effect on Mortality
Heart	2.904	0.514	0.114
Diabetes	−2.571	2.558	−0.023
Cancer	−3.654	5.665	0.012
Influenza or pneumonia	3.888	2.100	0.045
Infant mortality[a]	1.066	−1.369*	−0.035*

Note. We obtained the coefficient estimate from each model, in which we controlled for year, public clinics per 10 000 population, percentage female, unemployment rate, percentage non-White, percentage of population aged 65 years or older, total population, percentage of college graduates, percentage of non-English speakers, physicians per 100 000 population, hospital beds per 100 000 population, percentage of population living in poverty, percentage uninsured, and urban indicator. Mortality rates were calculated from 2005–2007 (for 2005) and 2008–2010 (for 2008).
Source. National Association of City and County Health Officials,[19] Centers for Disease Control and Prevention,[20] and Odum Institute at the University of North Carolina.[21]
[a]We obtained the coefficient estimate in the infant mortality model using the same control variables as for the other models, except that we removed the percentage of the population aged 65 years and older and added logged births.
*$P < .05$.

TABLE 4—Effect of Local Health Department Services on Infant Mortality: North Carolina, 2005 and 2008

Service	Coefficient	*P*
Clinical preventive	−0.006	.773
Family planning	−3.272	.102
EPSDT	−0.160	.785
Medical treatment	−0.035	.037
Prenatal care	−1.918	.009
Obstetrical care	−1.227	.01

Note. EPSDT = Early and Periodic Screening, Diagnosis, and Treatment, a program for Medicaid-eligible children. We obtained the coefficient estimate from each model, in which we controlled for year, public clinics per 10 000 population, percentage female, unemployment rate, percentage non-White, logged births, total population, percentage of college graduates, percentage of non-English speakers, physicians per 100 000 population, hospital beds per 100 000 population, percentage of population living in poverty, percentage uninsured, and urban indicator. Mortality rates were calculated from 2005–2007 (for 2005) and 2008–2010 (for 2008).

Source. National Association of City and County Health Officials,[19] Centers for Disease Control and Prevention,[20] and Odum Institute at the University of North Carolina.[21]

expected to influence mortality in the short term for these outcomes. In contrast, infant mortality is influenced by factors occurring over a relatively short time. Therefore, the effect of changes in services is more likely to be observed for this type of mortality than for other types of mortality in a short time period.

Our findings provide support for the work that LHDs are doing to improve infant health in their communities. Although it is not possible to directly attribute the improved infant mortality outcomes to LHD staffing and services, that we observed this association with a corresponding increase in the specific services designed to improve infant outcomes, and not for other, unrelated services, lends support to the conclusion that LHD staffing and services play a role in reducing the infant mortality rate. It also confirms previous research on this important association.

In our analyses, we controlled for community characteristics, including demographic characteristics of the population served and medical care–related resources. However, it is possible that the results are spurious or that unmeasured characteristics in an ecologically designed study may have contributed to the observed relationships. Ecological variables may also, in fact, have been endogenous and affected the observed results. For example, the economic conditions may have caused an increase in Medicaid enrollment, which may have affected both LHD services and infant mortality. We were also limited in our ability to examine interactions among spending, staffing, and services because of our focus on North Carolina and the resulting small sample size. In addition, the wide variation in observed spending levels by LHDs, along with the small sample size, further limited our potential to see an effect for spending.

Our research highlights the methodological difficulties of assessing the effect of services on outcomes. The National Association of City and County Health Officials data provided only whether the service was contracted for or provided by the LHD. They did not indicate the level of staffing or funding provided for individual services. Also, some services were uniformly provided (such as childhood immunizations), thus making it impossible to examine potential associations between the service and community outcomes. Finally, no data were available to measure the quality of services, which would certainly be expected to influence outcomes.

In this study, we examined the effect of spending, staffing, and services on mortality. We are conducting similar analyses of the relationship between LHD spending, staffing, and services and rates of selected preventive service use and morbidity rates. Results of these analyses may provide additional insights for local decision-makers. ■

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Contributors

A. P. Schenck and A. M. Meyer conceptualized and provided oversight for the study. T.-M. Kuo led the analyses. D. Cilenti led the dissemination efforts. All authors participated in the interpretation of the findings.

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Human Participant Protection

This study was approved by the University of North Carolina institutional review board under expedited review because of the use of existing or nonresearch data.

References

1. Willard R, Shah GH, Leep C, Ku L. Impact of the 2008-2010 economic recession on local health departments. *J Public Health Manag Pract.* 2012;18(2):106–114.

2. National Association of City and County Health Officials. Local health department job losses and program cuts: findings from the 2013 Profile Study. Available at: http://www.naccho.org/topics/infrastructure/lhdbudget/upload/Survey-Findings-Brief-8-13-13-3.pdf. Accessed April 27, 2014.

3. Baum NM, DesRoches C, Campbell EG, Goold SD. Resource allocation in public health practice: a national survey of local public health officials. *J Public Health Manag Pract.* 2011;17(3):265–274.

4. Meyer AM, Davis M, Mays GP. Defining organizational capacity for public health services and systems research. *J Public Health Manag Pract.* 2012; 18(6):535–544.

5. Altarum Institute, Centers for Disease Control and Prevention, Robert Wood Johnson Foundation, National Coordinating Center for Public Health Services and Systems Research. A national research agenda for public health services and systems. *Am J Prev Med.* 2012;42(5 suppl 1):S72–S78.

6. US Department of Health and Human Services, Office of Public Health and Science, Office of the Assistant Secretary for Health. Consensus statement on quality in the public health system. Available at: http://www.hhs.gov/ash/initiatives/quality/quality/phqf-consensus-statement.pdf. Accessed May 2, 2014.

7. Bovbjerg RR, Hatry HP. A formative assessment of PHSSR: preliminary findings. Available at: http://www.publichealthsystems.org/uploads/docs/KC13_UrbanInstitute_FormativeEvalofPHSSR.pdf. Accessed May 12, 2013.

8. Mays GP, Smith SA. Evidence links increases in public health spending to declines in preventable deaths. *Health Aff (Millwood)*. 2011;30(8):1585–1593.

9. Erwin PC, Greene SB, Mays GP, Ricketts TC, Davis MV. The association of changes in local health department resources with changes in state-level health outcomes. *Am J Public Health*. 2011;101(4):609–615.

10. Erwin PC, Mays GP, Riley WJ. Resources that may matter: the impact of local health department expenditures on health status. *Public Health Rep*. 2012;127(1):89–95.

11. Erwin PC. The performance of local health departments: a review of the literature. *J Public Health Manag Pract*. 2008;14(2):E9–E18.

12. Scutchfield FD, Knight EA, Kelly AV, Bhandari MW, Vasilescu IP. Local public health agency capacity and its relationship to public health system performance. *J Public Health Manag Pract*. 2004;10(3):204–215.

13. Mays GP, McHugh MC, Shim K, et al. Institutional and economic determinants of public health system performance. *Am J Public Health*. 2006;96(3):523–531.

14. Bhandari MW, Scutchfield FD, Charnigo R, Riddell MC, Mays GP. New data, same story? Revising studies on the relationship of local public health systems characteristics to public health performance. *J Public Health Manag Pract*. 2010;16(2):110–117.

15. Bekemeier B, Yang Y, Dunbar MD, Pantazia A, Grembowski DE. Targeted health department expenditures benefit birth outcomes at the county level. *Am J Prev Med*. 2014;46(6):569–577.

16. Hajat A, Cilenti D, Harrison LM, et al. What predicts local public health agency performance improvement? A pilot study in North Carolina. *J Public Health Manag Pract*. 2009j;15(2):E22–E33.

17. Porterfield DS, Reaves J, Konrad TR, et al. Assessing local health department performance in diabetes prevention and control—North Carolina 2005. *Prev Chronic Dis*. 2009;6(3):A87.

18. Mays GP, Smith SA. Geographic variation in public health spending: correlates and consequences. *Health Serv Res*. 2009;44(5 pt 2):1796–1817.

19. National Association of City and County Health Officials. National Profile of Local Health Departments survey data. 2005 and 2008. Available at: http://nacchoprofilestudy.org. Accessed September 26, 2012.

20. Centers for Disease Control and Prevention. Compressed mortality files, 2005–2010. Available at: http://wonder.cdc.gov/mortsql.html. Accessed January 31, 2015.

21. Odum Institute at the University of North Carolina. North Carolina vital statistics data, 2005–2010. Available at: http://arc.irss.unc.edu/dvn/dv/NCVITAL. Accessed January 31, 2015.

22. Gibbons RD, Hedeker D, DuToit S. Advances in analysis of longitudinal data. *Annu Rev Clin Psychol*. 2010;6:79–107.

23. Greenland S, Pearl J, Robin JM. Causal diagrams for epidemiologic research. *Epidemiology*. 1999;10(1):37–48.