Local Public Health Performance and its Impact on Population Health

by

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Abstract

Despite decades long calls for increased public health infrastructure, local health departments are still often overlooked. With continued and varied health threats being constantly posed, these health departments, which are considered to be the frontlines of public health practice, are being tested daily. All the while, many questions remain about the level of performance in local health departments and the mechanisms by which these health departments may become more effective in providing public health services to their communities.

In this dissertation, I first present an in-depth look at the current level of local health department performance on the Ten Essential Public Health Services. Using principal component analysis, we calculate health department specific scores for each of the essential services based on reported activities. With these scores, we explore the distribution of performance across services and the correlates of health department performance. We find that there is great variability on the performance of the essential services across health departments, but performance tends to be low overall. Total population served and health department per capita expenditures were both consistently associated with health department scores. Cluster analysis showed that there are six distinct score clusters, which can be defined by their overall performance level (high, moderate, or low performance) and whether they focus on policy and regulation or direct patient services. These findings suggest that health departments may be specializing their

services, to be more policy or patient service based, given their available resources or their role in their state's public health infrastructure.

We next explore a supplemental method to the current county health ranking systems. Ranking systems, such as the Robert Wood Johnson County Health Rankings, rank counties from first to last using morbidity, mortality and quality of life metrics. However, they do not include any sociodemographic context into the rankings, which leads to rankings that highlight the social inequities of health. While this is a valuable visual for the general public, and policy makers, it gives local health departments, who are well aware of these inequities, little new information. To explore this further, we created county health rankings driven by factors other than sociodemographic characteristics, which would provide health departments with new information on how they may improve their population's health. Using cluster analysis, we create county groupings based on the sociodemographic make-up of the county populations. Using the outcomes of obesity, smoking, and motor vehicle mortality, we compare nationwide county rankings to within cluster rankings. We find that the relative performance of many counties differs greatly if they are being compared to cluster peers instead of a nationwide ranking. These findings challenge the current practice of comparing localities with no consideration of their sociodemographic context, and propose that comparisons between similar populations may provide more opportunities for learning exchange.

Finally, we explore the premise that the activities local health departments perform positively impact health behaviors and outcomes in the populations they serve. Using hierarchical models, we examine the associations between local health department characteristics, including their scores on the Essential Public Health Services, and the

health outcomes of smoking, obesity, seatbelt use, and a self-reported rating of general health in individuals living in the populations being served. Increased scores on several of the Essential Public Health Services were significantly associated with decreased odds of poor health outcomes. Higher health department scores on "Inform, Educate, and Empower" and "Link to and Provide Care" were both significantly associated with a decreased odds of reporting poor or fair health. Increased scores on "Inform, Educate, and Empower" were also associated with decreased odds of smoking. Decreased odds of inconsistent seatbelt was significantly associated with higher scores on "Monitor Health Status" and "Enforce Laws and Regulations". While these associations between are noteworthy, perhaps the more remarkable finding was the strong and consistent relationship of people living in state governed local health departments having higher odds of poor health outcomes and behaviors than their locally governed counterparts after adjusting for the individual characteristics of the populations served and other health department characteristics.

As population health in the United States comes under increased scrutiny, the need for a strong public health infrastructure must be on the forefront of these conversations. In this dissertation, we attempt to highlight the importance of local health departments in this dialog. Future research, including robust longitudinal studies and validation of the scoring methodology used in this work, would further increase the understanding of how local health departments function and what steps can be taken to improve their performance. This work supports previous findings that local health departments make meaningful impacts on the populations they serve, but many of them

fall short of the expected level of capacity. A finding that I hope policy makers will note and work toward remedying.

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Chapter 1

Introduction

1.1 Health in the United States

Health gains in the United States, as measured by life expectancy and mortality, have stagnated in recent years, and even begun to worsen; and in 2015 life expectancy in the United States decreased for the first time in decades.[1] Additionally, the United States appears to be falling behind many of its industrialized peers in health metrics, and life expectancy is projected to continue to fall further behind other industrialized nations in the future.[2] However, health in the United States is far from uniform, with large disparities in health across the country that appear to be defined primarily by differences in socioeconomic status, and the health differences between the haves and have nots are continuing to widen.[3–5]

The overall stagnating health gains in the United States paired with the increasing health disparities make a strong case for a paradigm shift in how health services are delivered to communities. With continued political uncertainty surrounding the funding of clinical services, the importance of public health practice is becoming increasingly apparent. Historically, population level change in health status has been the calling card of public health. Public health interventions have been credited with majority of life expectancy increases over the past 200 years, yet discussion on the current role of public health has been mostly lacking in the public sphere.[6–8] This dissertation is focused on

exploring the current state of public health practice in the United States, specifically at the local level, and its potential role in making lasting impacts on the health of populations.

1.2 Public Health Infrastructure in the United States

The public health infrastructure in the United States is comprised of a network of federal, state, tribal and local health agencies, which are intended to work in concert.[9–11] The effectiveness of this system relies on each infrastructure level having the capacity to complete its required tasks.[12] These infrastructure levels each have differing legal roles, which define their responsibilities. Federal health agencies work in six main areas to impact population health: (1) policy making, (2) financing, (3) public health protection, (3) collecting and disseminating information, (4) capacity building, (5) direct management of services.[9,13] Federal health agencies have particular powers in environmental protection, occupational health and safety, and food and drug purity.[9,14] Although the federal government has capacity to guide public health practice within the United States, the primary responsibility for health falls to the state and local health departments. Under the 10th Amendment of the Constitution, the state and local health agencies retain the powers for ensuring the health of their populations. With states and localities all passing their own legislation and building their own public health systems, the U.S. public health infrastructure is fragmented, and quite diverse from location to location.[9,14,15]

In 1988, the Institute of Medicine released *The Future of Public Health* report, which described a governmental public health system that was in disarray, and provided a

road map for public health moving forward.[15] It was within this report that the mission of public health was defined as "fulfilling society's interest in assuring conditions in which people can be healthy".[15] The role of government health agencies in fulfilling this mission was outlined in the three core functions of public health practice: assessment of health status and health needs, policy development, and assurance that necessary services are provided. [9,15]

In response to the disorder described in the Institute of Medicine report, the Department of Health and Human Services convened the Public Health Functions Steering Committee in 1994. This committee was tasked with defining the basic public health services that every community should have access to.[16] This group defined Ten Essential Public Health Services, which expanded upon the core public health functions, serve as the basis of the nation's public health strategy, and provide a framework for public health performance evaluations such as the National Public Health Performance Standards.[17,18] The Essential Public Health Services are:

1. Monitor health status to identify and solve community health problems.
2. Diagnose and investigate health problems and health hazards in the community.
3. Inform, educate, and empower people about health issues.
4. Mobilize community partnerships and action to identify and solve health problems.
5. Develop policies and plans that support individual and community health efforts.
6. Enforce laws and regulations that protect health and ensure safety.
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable.

8. Assure competent public and personal health care workforce.
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.
10. Research for new insights and innovative solutions to health problems.

Despite the provision of a more concrete definition of what public health practice should look like, there has been continued concern about the status of the public health infrastructure in the United States. These concerns were brought to the forefront of the nation's attention in the fall of 2001, when the September 11th attacks, followed by a bioterrorism event in which individuals were exposed to anthrax laced mail, exposed many of the weaknesses in the public health system. These revelations spurred the Institute of Medicine's Committee on Assuring the Health of the Public in the 21st Century to further investigate public health capacity and provide an inclusive framework for action. The result was the 2003 report, *The Future of the Public's Health in the 21st Century,* which makes a compelling case for the need of increased public health capacity in order to ensure the nation's health. [9]

More recently, Healthy People 2020 and health department accreditation have placed further emphasis on public health capacity building.[19,20] Healthy People 2020 includes specific goals for the building of public health infrastructure which focus on a range of topics from workforce to data services, however many of the goals have not been reached, or are difficult to evaluate due to a lack of available data to measure progress.[19] Health department accreditation initially received great attention for its potential to build capacity through health departments striving to meet the thresholds for

being accredited, but it seems that local health department accreditation is slowing and many health departments view it as too much effort for little gain.[21,22]

Despite the many calls for bolstered public health practice over the years, it is unclear if meaningful improvements have been made, particularly at the local level. In part, this is because there is great diversity at the local level, and nationwide capacity has not been well described. In addition, there is little information on how local health departments impact the communities they serve, or what activities it is most important for local health departments to perform.

1.3 Local Public Health Performance

Local health departments may be the ideal public health institutions to lead the fight against the worsening health in the United States, as they are the most proximal institutions to the communities they serve and can cater their programs and services to suit their population's needs.[9,10,23] However, local health departments face many challenges in delivering quality public health services. Mainly, the health inequities that are being seen in the population are also being mirrored in the public health system, with those communities with the worst health outcomes being served by local health departments with the fewest resources.[23,24]

Evaluating local public health performance is challenging in itself for a variety of reasons. First, many of the current performance evaluation studies use opt in recruitment methods that often result in a sample with higher proportions of high performing health departments than are seen nationwide, leading to overestimates of nationwide capacity.[25] Additionally, many of the studies performed ask health departments to directly evaluate

their performance on the Ten Essential Public Health Services, likely leading to reporting bias. [25] Finally, some of the most commonly used evaluations are intended for the health department's own use, and therefore the results aren't aggregated into any standardized dataset that can be accessed for nationwide capacity or performance descriptions. [26] Despite these evaluation challenges, many studies have attempted to provide an estimate of local health department performance on the Ten Essential Public Health Services, with the majority of these studies finding that few health departments fulfill these basic functions. [9,25,27–32]

The lack of local health department capacity is not surprising when one considers the many challenges these organizations face. In recent years, many local health departments have faced funding and workforce decreases, making it challenging to maintain activities, and nearly impossible to add new ones. [33,34] This has put pressure on local health departments to become more specialized in the services they offer. [32] Local health departments also struggle to evaluate their own performance, both in relation to their capacity level and in outcomes in their own populations, primarily due to a lack of data. Local health department leaders have cited a lack of sufficiently granular and timely data as their main challenge in providing responses to public health concerns in their community. [35]

Due to the challenges in making comparisons between local health departments, their relative performance is often evaluated using measures like the County Health Rankings. [36] This ranking system, an effort led by the Robert Wood Johnson Foundation and the University of Wisconsin's Population Health Institute, ranks the counties in a state from first to last based on mortality and quality of life measures. [36] However, these

rankings may present even more difficulties for local health departments. The rankings often highlight the underlying health disparities and sociodemographic differences between counties, a topic that undoubtedly deserves visibility, but also one that the most disadvantaged health departments have little hope of tackling alone. Additionally, they give local health departments little information on how to improve their performance, as the counties ranking above them often simply have wealthier populations.

Despite the challenges being faced by local health departments, there is mounting evidence that the work that public health institutions do has a meaningful impact on the populations they serve. Recent studies have demonstrated associations between increased health department resources and decreases in measures of morbidity and mortality in the populations served. [11,37–41] Additionally, when local health department resources are reduced, performance on the Ten Essential Public Health Services also tends to decline, suggesting that performance on these services falls on the causal pathway for producing population level change. [29,42,43] The significant associations between local health department resources and the health outcomes in the communities they serve further highlight the potential for local health departments to have a meaningful impact on the health of the United States. This may be particularly true when considering health outcomes that are prime targets for public health interventions, such as the Centers for Disease Control and Prevention's (CDC) Winnable Battles, which are health outcomes that cause high levels of morbidity and mortality, but have known, effective public health interventions. [44]

1.4 Overview of Dissertation

The main objectives of this dissertation are to describe the current state of local public health capacity and performance in the United States, with a particular emphasis on the Ten Essential Public Health Services and to explore if differences in local health department characteristics, including their performance on the Ten Essential Public Health Services, impact the populations that they serve. Through the exploration of these two main aims, we hope to provide guidance to both federal agencies working to enhance local health department infrastructure and local health departments striving to improve the health of the people they serve.

Chapter 2 begins with an evaluation of local health department performance on the Ten Essential Public Health Services. Motivated by a lack of generalizable findings and methods susceptible to reporting bias in previous work, we measured performance using principal component analysis of the various activities local health departments reported performing in the National Association of City and County Health Officers Profile of Local Health Department's Survey. With this methodology we calculated scores for each essential service for 2,000 local health departments across the United States. This quantitative data allowed us to further investigate the distributions of health department performance and investigate the relationships between local health department characteristics and health department performance on the Essential Public Health Services. Cluster analysis was also performed to explore if health department performance clusters exist and the characteristics of these clusters were described.

Chapter 3 builds upon the idea of comparing community outcomes, and by proxy local health department performance, using metrics such as the Robert Wood Johnson

County Health Rankings. We propose that within state comparisons of counties may not always be the best way to accurately measure performance on health outcomes, and that comparing populations with similar sociodemographic make ups, regardless of state lines, could provide a new perspective on health department performance for their given context and supply an ideal group for learning exchange. To demonstrate this idea, we clustered counties in the United States based on their sociodemographic characteristics and then explored their percentile rank before and after clustering for several different health outcomes. Using this method, we show that context matters, and that counties that are considered high or low performers in a nationwide context may look quite different when compared to counties with similar sociodemographic characteristics. These comparisons to other similar populations provide health departments with an additional frame of reference by which to evaluate their performance.

Finally, in Chapter 4 we attempt to gain further understanding of the relationship between local health department performance and health outcomes in the populations they serve. Using hierarchical models, we evaluated the relationships between the local health department Essential Public Health Service scores presented in Chapter 2 and the odds of adverse health outcomes in individuals living in those health departments' jurisdictions. The findings in this chapter help to describe and further solidify our understanding of how health departments may positively impact the populations they serve.

References

1. Xu, JQ; Murphy, SL; Kochanek, KD; Arias E. Mortality in the United States, 2015. NCHS Data Brief, No 267. Hyattsville, MD; 2016.
2. Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. Lancet. 2017;389(10076):1323-1335. doi:10.1016/S0140-6736(16)32381-9.
3. Chetty R, Stepner M, Abraham S, et al. The Association Between Income and Life Expectancy in the United States, 2001-2014. Jama. 2016;315(16):1750-1766. doi:10.1001/jama.2016.4226.
4. Dwyer-Lindgren L, Bertozzi-Villa A, RW S, et al. Inequalities in life expectancy among us counties, 1980 to 2014: Temporal trends and key drivers. JAMA Intern Med. May 2017. http://dx.doi.org/10.1001/jamainternmed.2017.0918.
5. Wang H, Schumacher AE, Levitz CE, Mokdad AH, Murray CJ. Left behind: widening disparities for males and females in US county life expectancy, 1985-2010. Popul Health Metr. 2013;11(1):8. doi:10.1186/1478-7954-11-8.
6. Centers for Disease Control and Prevention (CDC). Ten great public health achievements--United States, 1900-1999. MMWR Morb Mortal Wkly Rep. 1999;48(12):241-243. http://www.ncbi.nlm.nih.gov/pubmed/10220250. Accessed June 27, 2017.
7. Centers for Disease Control and Prevention (CDC). Ten great public health achievements--United States, 2001-2010. MMWR Morb Mortal Wkly Rep.

2011;60(19):619-623. http://www.ncbi.nlm.nih.gov/pubmed/21597455. Accessed June 27, 2017.

8. Riley J. Rising Life Expectancy: A Global History. New York: Cambridge University Press; 2001.

9. Institute of Medicine Committee on Assuring the Health of the Public in the 21st Century. The Future of the Public's Health in the 21st Century.; 2002. doi:10.17226/10548.

10. National Association of City and County Health Officials. Operational Definition of a Functional Local Health Department. Washington, DC; 2005.

11. Hyde JK, Shortell SM. The structure and organization of local and state public health agencies in the U.S.: A systematic review. Am J Prev Med. 2012;42(5 SUPPL. 1). doi:10.1016/j.amepre.2012.01.021.

12. Trust for America's Health. Public Health Leadership Initiative: An Action Plan for Healthy People in Healthy Communities in the 21st Century. Washington, DC; 2006.

13. Boufford, J., Lee P. Health Policies for the 21st Century: Challenges and Recommendations for the U.S. Department of Health and Human Services. New York; 2001.

14. Gostin LO, Wiley LF. Public Health Law: Power, Duty, Restraint. University of California Press; 2000.

15. Institute of Medicine; Committee for the Study of the Future of Public Health; Division of Health Care Services. The Future of Public Health. Vol 33.; 1988. doi:10.1093/pubmed/fdr063.

16. Public Health Functions Steering Committee, Office of Disease Prevention and Health Promotion, Office of Health and Science UD of H and HS. Public Health in America. Washington, DC; 1994.

17. National Association of City and County Health Officials. National Public Health Performance Standards. http://archived.naccho.org/topics/infrastructure/NPHPSP/index.cfm. Published 2015. Accessed January 14, 2016.

18. Centers for Disease Control and Prevention. National Public Health Performance Standards. https://www.cdc.gov/nphpsp/. Published 2015. Accessed June 25, 2016.

19. US Department of Health and Human Services. Healthy People 2020. www.healthypeople.gov. Published 2010. Accessed June 27, 2017.

20. Public Health Accreditation Board. Public Health Department Accreditation Background. http://www.phaboard.org/about-phab/public-health-accreditation-background/. Published 2015. Accessed July 1, 2017.

21. Yeager VA, Ye J, Kronstadt J, Robin N, Leep CJ, Beitsch LM. National Voluntary Public Health Accreditation: Are More Local Health Departments Intending to Take Part? J Public Heal Manag Pr. 2015. doi:10.1097/phh.0000000000000242.

22. Riley WJ, Bender K, Lownik E. Public health department accreditation implementation: Transforming public health department performance. Am J Public Health. 2012;102(2):237-242. doi:10.2105/AJPH.2011.300375.

23. Berkowitz B. Rural public health service delivery: Promising new directions. Am J Public Health. 2004;94(10):1678-1681. doi:10.2105/AJPH.94.10.1678.

24. Harris JK, Beatty K, Leider JP, Knudson A, Anderson BL, Meit M. The Double Disparity Facing Rural Local Health Departments. Annu Rev Public Heal. 2016;37. doi:10.1146/annurev-publhealth-031914-122755.

25. Erwin PC. The performance of local health departments: a review of the literature. J Public Heal Manag Pr. 2008;14(2):E9-18. doi:10.1097/01.phh.0000311903.34067.89.

26. National Association of City and County Health Officials. Assessments. http://www.naccho.org/topics/infrastructure/mapp/framework/phase3.cfm. Published 2014. Accessed July 28, 2015.

27. Handler S, Turnock BJ. Local health department effectiveness in addressing the core functions of public health: essential ingredients. J Public Health Policy. 1996;17(4):460-483. doi:10.2307/3343103.

28. Turnock BJ, Handler AS, Miller CA. Core Function-Related Local Public Health Practice Effectiveness. J Public Heal Manag Pract. 1998;4(5):26-32. http://journals.lww.com/jphmp/Fulltext/1998/09000/Core_Function_Related_Local_Public_Health_Practice.5.aspx.

29. Mays GP, McHugh MC, Shim K, et al. Getting what you pay for: public health spending and the performance of essential public health services. J Public Health Manag Pract. 2004;10(5):435-443. http://www.ncbi.nlm.nih.gov/pubmed/15552769.

30. Mays GP, Halverson PK, Baker EL, Stevens R, Vann JJ. Availability and perceived effectiveness of public health activities in the nation's most populous communities. Am J Public Health. 2004;94(6):1019-1026. doi:10.2105/AJPH.94.6.1019.

31. Richards TB, Rogers JJ, Christenson GM, Miller CA, Taylor MS, Cooper AD. Evaluating local public health performance at a community level on a statewide basis. J Public Heal Manag Pr. 1995;1(4):70-83.

32. Bekemeier B, Pantazis A, Dunbar MD, Herting JR. Classifying Local Health Departments on the Basis of the Constellation of Services They Provide. Am J Public Health. 2014;104(12):e77-e82. doi:10.2105/AJPH.2014.302281.

33. National Association of City and County Health Officials. The Changing Public Health Landscape: Findings from the 2015 Forces of Change Survey. Washington, DC; 2015. http://nacchoprofilestudy.org/wp-content/uploads/2015/04/2015-Forces-of-Change-Slidedoc-Final.pdf.

34. Beck AJ, Boulton ML. Trends and characteristics of the state and local public health workforce, 2010-2013. Am J Public Health. 2015;(Suppl 2):S303-10. doi:10.2105/AJPH.2014.302353.

35. Castrucci BC, Rhoades EK, Leider JP, Hearne S. What Gets Measured Gets Done. J Public Heal Manag Pract. 2015;21:S38-S48. doi:10.1097/PHH.0000000000000169.

36. University of Wisconsin Population Health Institute. County Health Rankings Key Findings.; 2016.

37. Erwin PC, Mays GP, Riley WJ. Resources that may matter: the impact of local health department expenditures on health status. Public Health Rep. 2012;127:89-95. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3234401&tool=pmcentrez&rendertype=abstract.

38. Mays GP, Smith SA. Evidence links increases in public health spending to declines in preventable deaths. Health Aff. 2011;30(8):1585-1593. doi:10.1377/hlthaff.2011.0196.

39. Erwin PC, Greene SB, Mays GP, Ricketts TC, Davis M V. 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. doi:10.2105/AJPH.2009.177451.

40. Schenck AP, Meyer AM, Kuo T-M, Cilenti D. Building the Evidence for Decision-Making: The Relationship Between Local Public Health Capacity and Community Mortality. Am J Public Health. 2015;105(S2):S211-S216. doi:10.2105/AJPH.2014.302500.

41. Verma R, Clark S, Leider J, Bishai D. Impact of State Public Health Spending on Disease Incidence in the United States from 1980 to 2009. Health Serv Res. 2016;(Astho):1-15. doi:10.1111/1475-6773.12480.

42. 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. doi:10.2105/AJPH.2005.064253.

43. Remmert DM, O'Rourke T, Notaro SJ, Turnock B. Determinants of the Core Functions of Local Public Health Agencies. J Public Heal Manag Pract. 2013;19(6):575-581. doi:10.1097/PHH.0b013e318271c713.

44. Centers for Disease Control and Prevention. Winnable Battles. https://www.cdc.gov/winnablebattles/. Accessed February 28, 2017.

Chapter 2

What Do Local Health Departments Do? Performance and Approaches to Essential Public Health Services.

2.1 Abstract

Objective: To quantify self-reported local health department performance on the Ten Essential Public Health Services and describe the relationships between performance and institutional characteristics.

Methods: We used data on 2000 local health departments from the 2013 National Profile of Local Health Department survey, conducted by the National Association of County and City Health Officials to develop principal component analysis based scores for each health department on the essential public health services.

Results: Performance scores varied greatly across health departments and across essential public health services, however health departments typically scored below 50, indicating that they performed less than half of the activities evaluated. Local health department performance showed significant positive associations with population size and per capita funding.

Conclusions: Our results suggest weaknesses in many local health department's fulfillment of the essential public health services, particularly with in low population and

low funding settings. We further find differences in local health department focus associated with governance and funding levels.

Policy implications: This study provides a snapshot of health department performance across the United States and lays out a methodology for understanding our public health infrastructure.

2.2 Introduction

The public health infrastructure in the United States is comprised of a network of federal, state and local health agencies intended to work in concert.[1,2] The effectiveness of this system relies on each level having the capacity to complete its required tasks.[3] In 1994, the Public Health Functions Working Group defined the 10 Essential Public Health Services (EPHS) that serve as benchmark for public health practice (Table 1).[4] Fulfillment of the EPHS by local health departments is vital as they are the most proximal health agency to the communities they serve.[1,2] However, a growing body of literature suggests that the capacity of local health departments to provide public health services varies greatly, and may be weak overall.[1,5–12]

Concerns over lack of capacity have led to a push for public health infrastructure improvements through programs such as Healthy People 2020 and health department accreditation.[13,14] However, many of these goals remain unmet.[15,16] Additionally, there is no clear baseline for local public health performance. Studies investigating local public health performance tend to focus on the most populous cities or health departments that have opted into programs such as the National Public Health Performance Standards Program;[8,10,17–19] hence may overestimate nationwide capacity.[10,19]

Here we evaluate the self-reported capacity of local public health departments using scores derived from principal components analysis. We quantify the performance of 2,000 local health departments on each of the 10 EPHS with an eye towards objectively measuring performance across a heterogeneous group of health departments.

We further explore the relationships between health department performance and institutional characteristics.

2.3 Methods

2.3.1 Study Data

Our analysis uses data from the National Association of City and County Health Officers (NACCHO) 2013 National Profile of Local Health Departments.[20] The NACCHO study enumerated 2,532 local health departments, 2,000 (79%) of which responded to the core survey. Health departments were randomly selected to receive just the core questionnaire or the core plus one of two supplemental modules. Seventy-nine percent of those that received supplemental module 1 and 82% of those that received supplemental module 2 responded.

2.3.2 Measures of Essential Public Health Service Performance

Reported health department activities were categorized into EPHS categories based on metrics used in previous health department evaluations (Appendix 1).[2,21,22] Activities only relevant for localities with particular industries were excluded (e.g. correctional health or radiation control). Some of the activities used in describing EPHS 4, EPHS 8, EPHS 9, and EPHS 10 came from module 1 of the questionnaire, therefore the analysis for these EPHS had a reduced sample size (N=490).

2.3.3 Data Analysis

We used principle components analysis (PCA) to derive an EPHS specific score (the principle component) derived form a linear combination of responses that captures the majority of the variability in the data on that service. Because many variables were discrete, we used polychoric correlation matrices of the variables of interest.[23] Our analysis focuses only on the principle components, which explain an average of 53.5% of the combined variances in the variables used, versus 13.8% for secondary components. We highlight those variables with the largest contribution to the score (i.e., those with a correlation of >25%) (Table 1).

Each EPHS score was normalized to range from 0 to 100 such that those health departments performing all of the activities within a given essential service have a score of 100 and those health departments performing none of the activities have a score of 0.

We used multivariate linear regression to examine the association between EPHS scores and population size, per capita health department expenditures, health department governance classification (local, state, or shared governance), and presence of a local board of health. Population size and per capita expenditures were modeled on the log scale to maintain a linear relationship with the dependent variables. Correlations between health departments in the same state were accounted for using clustered standard errors.

To explore if there are natural groupings of local health departments that share the same strengths and weaknesses, clusters were created based on health department EPHS scores using Gaussian finite mixture modeling as implemented in the mclust R package.[24,25] This approach creates clusters of health departments based on similarities in their score profiles across the EPHSs. We compared the characteristics of EPHS based

clusters (e.g. governance, per capita expenditures), and assessed associations using chi-squared and ANOVA significance tests. Data were analyzed using R v3.3.2. [26]

2.4 Results

Results are summarized in Table 1, which identifies those factors that best capture local health department performance for each EPHS; and Table 2, which provides summary statistics and the distribution of health department scores for each EPHS.

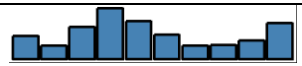
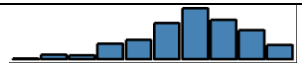
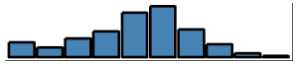
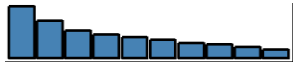
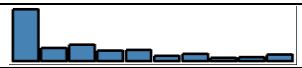
Health departments performed well on EPHS 1 (monitor health status to identify and solve community health problems), with the majority scoring above 50. A typical (i.e., scoring near the median) local health department performed 4 of 7 surveillance activities and completed a community health assessment within the prior five years. Communicable disease surveillance was the most frequently reported activity (91.2%; 1,802/1,975), while injury surveillance was the least common (27.3%; 522/1,910).

For EPHS 2 (diagnose and investigate health problems and health hazards in the community), a typical local health department performed 4 of 8 disease screening activities and provided no laboratory services. Tuberculosis screening was the most frequently reported activity (83.7%; 1,650/1,971), while cardiovascular disease screening was the least common (27.3%; 523/1915).

Table 2.1: Activities Best Capturing EPHS Performance and the Combined Variance in the Activities Used that is Explained by the Principal Component

Essential Public Health Service	Activities Best Capturing EPHS Performance, in Order of Importance	Variance Explained (%)
1. Monitor health status to identify and solve community health problems	Infectious disease surveillance, injury surveillance, behavioral risk factor surveillance, chronic disease surveillance, maternal and child health surveillance, syndromic surveillance, environmental health surveillance	56.7
2. Diagnose and investigate health problems and health hazards in the community	Screening for diabetes, cardiovascular disease, cancer, tuberculosis, high blood pressure, HIV, blood lead, provision of laboratory services	52.2
3. Inform, educate, and empower people about health issues	Population-based primary prevention activities for physical activity, violence, chronic disease, nutrition, tobacco, substance abuse, injury, mental illness, unintended pregnancy	57.6
4. Mobilize community partnerships to identify and solve health problems	Collaborated with other community partners on maternal and child health, infectious disease, chronic disease, environmental health, community health assessments, food safety, tobacco, alcohol or other drugs, emergency preparedness	42.0
5. Develop policies and plans that support individual and community health efforts	Provision of technical assistance to policy makers, regulatory or advocacy groups for drafting proposed legislation, regulations, or ordinances, preparation of issue briefs regarding proposed policy, provision of public testimony regarding proposed policy, participation on a board or advisory panel responsible for public health policy	51.5
6. Enforce laws and regulations that protect health and ensure safety	Regulation, inspection, and/or licensing of food service establishments, ground water protection, surface water protection, private drinking water, air pollution, public drinking water, schools and daycares, indoor air quality, health facilities	45.1
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable	Provision of child immunization, family planning, STD treatment, adult immunizations, tuberculosis treatment, WIC food and nutrition services	41.0
8. Assure competent public and personal health care workforce	Use of core competencies for public health workers for conducting staff performance evaluations, assessing staff training needs, developing staff training plans, writing job descriptions.	67.4
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.	Performance of quality improvement (QI) activities, existence of agency wide QI plan, QI committee, dedicated QI staff member, dedicated resources for QI, provision of QI resources and training to staff on an ongoing basis, use of performance data to drive improvement efforts	52.6
10. Research for new insights and innovative solutions to health problems	Development of research protocols, dissemination of findings to stakeholders, collection, exchange, or report of study data, analysis and interpretation of study data, identification of research topics relevant to public health practice, recruitment of study participants, support of organizations applying research findings to practice, and application of research findings to practices within their own organization.	68.5

Table 2.2: Sample Size, Median Score, Number of Health Departments Performing No Activities, Number of Health Departments Performing All Activities, and Distribution of Health Department Scores for Each EPHS

Essential Public Health Service	Sample N=2000 (%)	Median Score (IQR)	Performed No Activities n (%)	Performed All Activities n (%)	Local Health Department Score Distributions
1. Monitor health status to identify and solve community health problems	1,834 (91.7%)	63.5 (46.1-80.9)	32 (1.7%)	178 (9.7%)	
2. Diagnose and investigate health problems and health hazards in the community	1,467 (73.4%)	42.0 (28.1-72.0)	91 (6.2%)	71 (4.8%)	
3. Inform, educate, and empower people about health issues	1,836 (91.8%)	41.1 (17.9-66.6)	108 (5.9%)	76 (4.1%)	
4. Mobilize community partnerships to identify and solve health problems	451 (22.6%)	65.4 (53.7-77.5)	1 (0.2%)	7 (1.6%)	
5. Develop policies and plans that support individual and community health efforts	1,832 (91.6%)	58.7 (26.9-81.7)	86 (4.7%)	89 (4.9%)	
6. Enforce laws and regulations that protect health and ensure safety	1,796 (89.8%)	42.0 (23.8-58.7)	151 (8.4%)	18 (1.0%)	
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable	1,767 (88.4%)	48.2 (34.1-58.7)	80 (4.5%)	1 (0.1%)	
8. Assure competent public and personal health care workforce	470 (23.5%)	0.0 (0.0-22.9)	347 (73.8%)	29 (6.2%)	
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.	473 (23.7%)	29.7 (12.2-55.7)	53(11.2%)	7 (1.5%)	
10. Research for new insights and innovative solutions to health problems	463 (23.2%)	10.6 (0.0-23.8)	183 (39.5%)	21 (4.5%)	

For EPHS 3 (inform, educate, and empower people about health issues), a typical local health department performed 3/9 population-based primary prevention activities and provided food safety education. Food safety education was the most frequently reported activity (73.1%; 1,428/1,954), while mental illness programs were the least common (12.4%; 240/1,933).

EPHS 4 (mobilize community partnerships to identify and solve health problems) had the highest scores overall, indicating that most local health departments are working with their community partners. These partnerships were evaluated on a scale ranging from the low end of having no involvement with outside partners, followed by networking, coordinating, cooperating, and collaborating, with collaboration being the highest level of partnership. A typical local health department coordinated their efforts with partners on most topics, but only rarely reported full collaboration on activities. Emergency preparedness was the most frequently reported collaboration activity (collaboration performed by 70.1%; 338/482), while land use collaboration was the least common (5.6%; 26/468).

For EPHS 5 (develop policies and plans that support individual and community health efforts), a typical local health department had strategic and community health improvement plans, but these had not been updated in the previous 5 years. They also participated in some policy-making activities, but had not passed a new public health ordinance in the past 2 years. Communicating with legislators was the most frequently reported activity (79.4%; 1,350/1,945), while adopting a new public health ordinance or legislation was the least common (36.8%; 719/1,954).

For EPHS 6 (enforce laws and regulations that protect health and ensure safety), a typical local health department performed 5/13 regulatory activities. Regulation, inspection, and/or licensing of food services establishment was the most frequently reported activity (78.5%; 1540/1,962), while regulation, inspection, and/or licensing of cosmetology businesses was the least common (12.3%; 235/1,913).

For EPHS 7 (link people to needed personal health services and assure the provision of health care when otherwise unavailable), a typical local health department performed 8/20 health services. Adult immunization was the most frequently reported activity (90.6%; 1,789/1,975), while substance abuse services were the least common (7.4%; 143/1,940).

EPHS 8 (assure competent public and personal health care workforce) had the lowest health department scores overall, with a median score of 0. A typical health department did not use core public health competencies for any employee hiring or training actives. Use of core competencies for evaluating training needs was the most frequently reported activity (directly performed by 18.9%; 89/470), while use of core competencies in job descriptions was the least common (13.4%; 63/470).

For EPHS 9 (evaluate effectiveness, accessibility, and quality of personal and population-based health services), a typical local health department reported informal or ad hoc quality improvement (QI) activities, with no consistent resources dedicated to QI. Formal or informal QI activities were reported by most health departments (performed by 88.9%; 424/477), however a minority of health departments reporting QI activities had specific resources dedicated to QI (43.6%; 185/424).

Health departments scored poorly on EPHS 10 (research for new insights and innovative solutions to health problems), with 39.5% performing none of the research activities evaluated. A typical local health department performed 1/8 research activities. Collecting, exchanging, or reporting data for a study was the most frequently reported activity (performed by 40.4%; 187/463), while developing or refining research plans and/or protocols for public health practice was the least common (12.5%; 58/463).

We considered the impact of population size, health department per capita expenditures, governance classifications and the presence of a local board of health on EPHS scores. The mean population of the jurisdictions included was 155,200 (SD=441,127). The mean local health department expenditures, per capita, were $55.54 (SD=101.11). A health department being a unit of the local government was the most common governance classification (77.0%; 1,163/1,511), followed by being unit of state government (12.1%; 183/1,511). Combined state and local governance was the least common governance classification (10.9%; 165/1,511). A majority of local health departments reported having a local board of health (73.9%; 1,116/1,511).

Those local health departments serving larger populations and with more funding, tended to perform more activities related to the EPHSs, and have higher scores (Table 3). However, expenditures were unrelated to the number of enforcement activities a local health department performed (as captured by EPHS 6) or the use of core competencies for the public health workforce (EPHS 8). The presence of a local board of health did not seem to have a consistent impact on EPHS scores, however health departments with a local board of health did score 8.1 points higher on average (95% CI 3.6, 12.7) on

activities related to informing, educating, and empowering people about health issues (EPHS 3).

Health departments governed at the local level scored higher on activities related to local health policy (EPHS 5) compared to state governed departments, which on average scored 36.2 points less on EPHS 5 (95% CI -48.2, -23.2). Health departments governed at the state level scored higher on activities related to the linkage to and provision of healthcare (EPHS 7) and the assurance of a competent workforce (EPHS 8), scoring on average 15.1 points higher on EPHS 7 (95% CI 3.2, 27.1) and 14.5 points higher on EPHS 8 (95% CI 5.4, 23.5) than locally governed health departments. Health departments governed at both the state and local level scored higher on activities related to diagnosis and investigation health problems (EPHS 2) and the evaluation of population based health services (EPHS 9) scoring on average 20.8 points higher on EPHS 2 (95% CI 7.0, 34.6) and 16.4 points higher on EPHS 9 (95% CI 4.7, 28.0).

Table 2.3: Influence of Selected Characteristics on Local Health Department EPHS Scores

Characteristic	Average Difference in Score on EPHS									
	EPHS 1 (n=1,407)	EPHS 2 (n=1,148)	EPHS 3 (n=1,397)	EPHS 4 (n=344)	EPHS 5 (n=1,403)	EPHS 6 (n=1,378)	EPHS 7 (n=1,364)	EPHS 8 (n=366)	EPHS 9 (n=366)	EPHS 10 (n=358)
Population of jurisdiction (log)	5.9 (3.8, 7.9)[c]	3.2 (1.0, 5.3)[b]	5.6 (4.1, 7.1)[c]	3.9 (2.6, 5.1)[c]	8.1 (6.8, 9.5)[c]	5.6 (2.7, 8.5)[c]	4.1 (2.4, 5.9)[c]	1.7 (-0.17, 3.7)	5.4 (3.3, 7.6)[c]	8.1 (6.9, 9.3)[a]
Per capita expenditures (log)	8.9 (5.6, 12.2)[c]	10.7 (6.1, 15.2)[c]	11.6 (8.5, 14.7)[c]	3.6 (1.2, 6.0)[b]	4.4 (1.9, 7.0)[c]	0.2 (-5.1, 5.6)	11.4 (8.2, 14.7)[c]	0.2 (-3.4, 3.8)	4.6 (0.1, 9.1)[a]	4.9 (2.5, 7.2)[a]
Governance classification										
Unit of state government	-2.3 (-17.6, 12.9)	9.5 (-13.1, 32.1)	5.4 (-20.2, 31.0)	-2.5 (-10.6, 5.7)	-36.2 (-48.2, -23.2)[c]	-10.2 (-18.4, -2.1)[a]	15.1 (3.2, 27.1)[a]	14.5 (5.4, 23.5)[b]	13.8 (-15.0, 42.7)	-9.9 (-18.1, -1.8)[c]
Governed by both state and local	5.0 (-1.0, 11.0)	20.8 (7.0, 34.6)[b]	8.2 (3.0, 13.5)[b]	2.5 (-3.8, 8.7)	3.3 (0.3, 6.2)[a]	0.2 (-10.5, 10.8)	11.0 (3.1, 18.9)[b]	9.1 (-3.7, 22.0)	16.4 (4.7, 28.0)[b]	-3.4 (-9.7, 2.8)
Reference: unit of local government	-	-	-	-	-	-	-	-	-	-
Local board of health	3.7 (0.5, 6.9)[a]	0.6 (-5.0, 6.3)	8.1 (3.6, 12.7)[c]	-1.7 (-6.3, 3.0)	3.0 (-0.6, 6.6)	2.4 (-3.3, 8.0)	1.0 (-2.0, 4.1)	3.4 (-2.9, 9.6)	7.6 (0.3, 15.0)[a]	-1.6 (-6.2, 3.1)

[a] ***p-value<0.05***, [b] ***p-value<0.01***, [c] ***p-value<0.001***

To maximize the number of health departments considered, we ran the cluster analysis using only those EPHSs with activities included on the core questionnaire, which included EPHS 1: Monitor Health Status; EPHS 2: Diagnose and Investigate; EPHS 3: Inform, Educate, and Empower; EPHS 5: Develop Policy; EPHS 6: Enforce Laws and Regulations; and EPHS 7: Link to and Provide Care. We identified six performance based local health department clusters (Table 4). Two of these had high mean EPHS scores, two had moderate scores, and two had relatively poor average scores. With one or two exceptions, high scoring clusters had higher mean scores across all EPHSs. However, within scoring tiers health departments could be divided between those that emphasize policy and regulation (e.g. EPHS 5: Develop Policy and EPHS 7: Enforce Laws and Regulations) and those with varying levels of increased emphasis on direct patient services (e.g. EPHS 2: Diagnose and Investigate, EPHS 3: Inform, Educate and Empower, and EPHS 7: Link to and Provide Care). This division was especially stark in the low scoring tier.

Of the two clusters in the high performance tier, the Policy and Regulation Cluster had particularly high scores in monitoring health status (EPHS 1) and policy development (EPHS 5), but scored moderately in linkage to and provision of care (EPHS 7). The high performance Direct Patient Services Cluster specialized in diagnosis and investigation (EPHS 2) and had a relatively low scores for enforcement of laws and regulations (EPHS 6). In the moderate performance tier, the Policy and Regulation Cluster had moderate EPHS scores overall, but had similar performance strengths and weaknesses to high performance Policy and Regulation Cluster. The moderate tier Direct Patient Services Cluster scored moderately well on monitoring health status and linkage to and provision

of care, but scored poorly in policy development. In the low performance tier, the Policy and Regulation Cluster had the lowest average overall score but scored moderately well in policy development and enforcement of laws and regulations. The Direct Patient Services Cluster scored moderately well on inform, educate and empower (EPHS 3) and linkage to and provision of care, but scored poorly in enforcement of laws and regulations. We also clustered health departments based on their scores across all 10 EPHSs (n=266). This analysis revealed two health department clusters, differing primarily by average scores on assurance of a competent workforce (EPHS 8) and research (EPHS 10).

The health department clusters differ significantly by size of the population served, with the high performance tier having the highest mean populations and the low performance tier having the lowest mean populations ($P<0.01$) (Table 4). Clusters also differed significantly by their per capita expenditures with the high performance tier spending the most overall ($P<0.01$). The groups also have significant differences in their governance classifications, with the Policy and Regulation clusters tending to be more frequently locally governed ($P<0.01$). Additionally, the Policy and Regulation clusters were more likely to have a local board of health than the Direct Patient Services clusters ($P=0.01$).

Table 2.4: Local Health Department Clusters with Cluster Specific Mean Scores on Each EPHSs and Associations Between Local Health Department Clusters and Health Department Characteristics.

	High Performance Tier		Moderate Performance Tier		Low Performance Tier		
	Policy and Regulation Cluster (n=254)	Direct Patient Services Cluster (n=167)	Policy and Regulation Cluster (n=308)	Direct Patient Services Cluster (n=214)	Policy and Regulation Cluster (n=89)	Direct Patient Services Cluster (n=113)	p-value
Cluster Descriptions							
Cluster Mean Score							
EPHS 1: Monitor Health Status	83.0	72.4	66.5	52.4	33.1	39.7	-
EPHS 2: Diagnose and Investigate	59.6	89.9	38.3	37.9	6.4	31.7	-
EPHS 3: Inform, Educate, and Empower	61.0	60.6	46.0	33.8	12.2	40.7	-
EPHS 5: Develop Policy	90.0	55.3	62.7	13.1	52.3	46.2	-
EPHS 6: Enforce Laws and Regulations	59.8	40.4	44.8	32.7	53.4	2.1	-
EPHS 7: Link to and Provide Care	53.7	63.5	46.5	49.5	8.5	40.8	-
Institutional Characteristics of Cluster Members							
Mean population of jurisdiction in thousands, (SD)	326.3 (870.9)	138.5 (329.7)	116.5 (211.3)	82.2 (169.2)	69.4 (126.3)	114.5 (348.8)	<0.01
Mean per capita expenditures, $, (SD)	84.5 (229.7)	72.3 (60.0)	51.9 (57.5)	48.2 (37.4)	17.3 (17.7)	60.4 (68.8)	<0.01
Governance classification, *n* (%)							<0.01
Unit of local government	202 (79.5)	85 (50.9)	241 (78.2)	93 (43.5)	88 (98.9)	90 (79.6)	-
Shared governance	42 (16.5)	36 (21.6)	18 (5.8)	3 (1.4)	0 (0.0)	5 (4.4)	-
Unit of state government	10 (3.9)	46 (27.5)	49 (15.9)	118 (55.1)	1 (1.1)	48 (15.9)	-
Local board of health, *n* (%)	192 (76.5)	109 (65.3)	226 (73.6)	134 (63.2)	66 (74.2)	36 (66.4)	0.01

2.5 Discussion

Overall, our analysis indicates local health departments have room for improvement on EPHS performance. For all but 3 of the EPHSs, the median score was less than 50, indicating that most local health departments performed less than half of the activities key to these services. Health department performance varied widely. For each EPHS there was at least one health department that performed none of the activities measured (i.e., scored 0) and at least one that performed all of the activities (i.e., scored 100). The often high frequency of low sores further emphasizes the continued need for improvements in public health infrastructure. [5–8]

There was substantial variability in performance between EPHSs. On average, local health departments reported the highest performance in monitoring population health, mobilizing community partnerships, and developing public health policies and plans. Health departments had the lowest scores overall for assuring a competent workforce, evaluating population based health services, and performing research. Notably, the majority of health departments (73.8%) scored zero on EPHS 8, indicating that they do not use core public health competencies in any workforce recruitment or development activities.

Findings from the multivariate model support previous studies that show health department performance increases with the size of the population served and per capita health department spending.[7,9,10,19,27–29] Health department governance structure displayed interesting relationships with EPHS performance scores in our model. Local health departments that were state governed had significantly lower scores in local level policy

making, enforcement of laws and regulations, and research than did locally governed health departments. However, state governed local health departments had significantly higher scores in linkage to and provision of health care and assurance of a competent workforce. Health departments with shared state and local governance often scored better than their locally governed counterparts. These patterns in EPHS performance by governance structure are likely driven in part by differences in health department responsibilities based on governance structures, with state governed and locally governed local health departments serving different purposes within a state's public health infrastructure.

EPHS score based cluster analysis suggests local health departments may specialize in particular EPHS areas, consistent with findings of previous studies.[27,28,30] While there were clusters that scored high or low across services, there is some suggestion of qualitative differences between clusters. This suggests that given resource or political limitations, health departments may be focusing on particular areas, while leaving others behind. There may also be differences in the local mandates of health department clusters. The associative analysis between health department structural characteristics and the health department clusters also highlight important potential drivers of health department priorities. As expected, the high performing health department clusters had larger populations and higher per capita expenditures on average. Additionally, the health department governance and presence of a local health department appears to be related to the types of services a health department provides.

This study has several important limitations. Although this study is drawn from a sampling frame that includes all local health departments, there was differential response

by population size, with those health departments serving smaller populations being less likely to respond. Health departments serving populations <25,000 had the lowest response rate overall (72% vs 79% overall; p-value<0.05). Based on the associations seen between population and health department performance in our model, this may indicate that our findings are overestimates of nationwide EPHS performance.

Although the activities included in the PCAs were informed by expert opinion, we were limited to the questions asked by the NACCHO survey and did not cover all activities necessary for fulfillment of each EPHS. Furthermore, many of the surveillance activities we included in EPHS 1 are often included in EPHS 2. However, we felt these activities fit well within the "monitor health" description of EPHS 1, and given our limited question availability, we choose to categorize these within EPHS 1 instead of EPHS 2. Additionally, scores were derived from statistical relationships identified in principal components analysis, and not on any indication that a particular activity was more or less important for performance. That is, highly loaded variables should be considered indicators rather than drivers of performance. Finally, our analysis was based on self-reported performance of particular activities, not how well those activities were performed.

2.6 Public Health Implications

This study broadly characterizes the performance of local health departments in the United States, using the EPHSs as a guide. Understanding the level of EPHS performance by local health departments, and the variations in that performance, is fundamental in evaluating population access to critical public health services. These

findings allow us to identify underserved populations and evaluate correlates to health department performance, which serve to guide performance improvement efforts.

References

1. Institute of Medicine Committee on Assuring the Health of the Public in the 21st Century. *The Future of the Public's Health in the 21st Century*.; 2002. doi:10.17226/10548.

2. National Association of City and County Health Officials. *Operational Definition of a Functional Local Health Department*. Washington, DC; 2005.

3. Trust for America's Health. *Public Health Leadership Initiative: An Action Plan for Healthy People in Healthy Communities in the 21st Century*. Washington, DC; 2006.

4. Public Health Functions Steering Committee, Office of Disease Prevention and Health Promotion, Office of Health and Science US Department of Health and Human Services. *Public Health in America*. Washington, DC; 1994.

5. Turnock BJ, Handler A, Hall W, Potsic S, Nalluri R, Vaughn EH. Local Health Department Effectiveness in Addressing the Core Functions of Public Health. *Source Public Heal Reports*. 1994;109(5):653-658. doi:10.2307/3343103.

6. Turnock BJ, Handler AS, Miller CA. Core Function-Related Local Public Health Practice Effectiveness. *J Public Heal Manag Pract*. 1998;4(5):26-32. http://journals.lww.com/jphmp/Fulltext/1998/09000/Core_Function_Related_Local_Public_Health_Practice.5.aspx.

7. Richards TB, Rogers JJ, Christenson GM, Miller CA, Taylor MS, Cooper AD. Evaluating local public health performance at a community level on a statewide basis. *J Public Heal Manag Pr*. 1995;1(4):70-83.

8. Mays GP, Halverson PK, Baker EL, Stevens R, Vann JJ. Availability and perceived effectiveness of public health activities in the nation's most populous communities. *Am J Public Health*. 2004;94(6):1019-1026. doi:10.2105/AJPH.94.6.1019.

9. Mays GP, McHugh MC, Shim K, et al. Getting what you pay for: public health

spending and the performance of essential public health services. *J Public Health Manag Pract*. 2004;10(5):435-443. http://www.ncbi.nlm.nih.gov/pubmed/15552769.

10. Erwin PC. The performance of local health departments: a review of the literature. *J Public Heal Manag Pr*. 2008;14(2):E9-18. doi:10.1097/01.phh.0000311903.34067.89.

11. Frieden TR. Asleep at the switch: local public health and chronic disease. *Am J Public Heal*. 2004;94(12):2059-2061.

12. Suen J, Magruder C. National profile: overview of capabilities and core functions of local public health jurisdictions in 47 states, the District of Columbia, and 3 U.S. territories, 2000-2002. *J Public Health Manag Pract*. 2004;10(1):2-12. http://www.scopus.com/inward/record.url?eid=2-s2.0-1642566553&partnerID=40&md5=1df238b353adb8bb8f68f2d301001202.

13. Riley WJ, Bender K, Lownik E. Public health department accreditation implementation: Transforming public health department performance. *Am J Public Health*. 2012;102(2):237-242. doi:10.2105/AJPH.2011.300375.

14. Office of Disease Prevention and Health Promotion. US Department of Health and Human Services. Public Health Infrastructure. https://www.healthypeople.gov/2020/topics-objectives/topic/public-health-infrastructure. Published 2016. Accessed October 7, 2016.

15. National Center for Health Statistics. *Healthy People 2010 Final Review*. Hyattsville, MD; 2012.

16. Centers for Disease Control and Prevention; United States Senate; Committee on Appropriations. *Public Health's Infrastructure; a Status Report*. Washington, DC; 2001.

17. Bhandari MW, Scutchfield FD, Charnigo R, Riddell MC, Mays GP. New data, same story? Revisiting studies on the relationship of local public health systems characteristics to public health performance. *J Public Health Manag Pract*.

2010;16(2):110-117. doi:10.1097/PHH.0b013e3181c6b525.

18. Mays GP, Scutchfield FD, Bhandari MW, Smith SA. Understanding the organization of public health delivery systems: an empirical typology. *Milbank Q*. 2010;88(1):81-111. doi:10.1111/j.1468-0009.2010.00590.x.

19. Hyde JK, Shortell SM. The structure and organization of local and state public health agencies in the U.S.: A systematic review. *Am J Prev Med*. 2012;42(5 SUPPL. 1). doi:10.1016/j.amepre.2012.01.021.

20. National Association of City and County Health Officials. *2013 National Profile of Local Health Departments*. Washington, DC; 2014. WWW.nacchoprofilestudy.org.

21. Schenck AP, Meyer AM, Kuo T-M, Cilenti D. Building the Evidence for Decision-Making: The Relationship Between Local Public Health Capacity and Community Mortality. *Am J Public Health*. 2015;105(S2):S211-S216. doi:10.2105/AJPH.2014.302500.

22. National Association of City and County Health Officials. National Public Health Performance Standards. http://archived.naccho.org/topics/infrastructure/NPHPSP/index.cfm. Published 2015. Accessed January 14, 2016.

23. Kolenikov S, Angeles G. The Use of Discrete Data in PCA: Theory, Simulations, and Applications to Socioeconomic Indices. *Chapel Hill Carolina Popul Center, Univ North Carolina*. 2004:1-59.

24. Fraley, Chris; Raftery, Adrian E.; Murphy, T. Murphy; Scrucca L. mclust Version 4 for R: Normal Mixture Modeling for Model-Based Clustering, Classification, and Density Estimation Technical Report No. 597. 2012.

25. Fraley, Chris; Raftery AE. Model-based Clustering, Discriminant Analysis and Density Estimation. *J Am Stat Assoc*. 2002;(97):611-631.

26. Team Rs. RStudio: Integrated Development for R. RStudio, Inc. 2016. http://www.rstudio.com/.

27. 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. doi:10.2105/AJPH.2005.064253.

28. Harris JK, Beatty K, Leider JP, Knudson A, Anderson BL, Meit M. The Double Disparity Facing Rural Local Health Departments. *Annu Rev Public Heal*. 2016;37. doi:10.1146/annurev-publhealth-031914-122755.

29. Handler a S, Turnock BJ. Local health department effectiveness in addressing the core functions of public health: essential ingredients. *J Public Health Policy*. 1996;17(4):460-483. doi:10.2307/3343103.

30. Berkowitz B. Rural public health service delivery: Promising new directions. *Am J Public Health*. 2004;94(10):1678-1681. doi:10.2105/AJPH.94.10.1678.

Appendix 2A: Activities Categorized into Each Essential Public Health Service

Essential Public Health Service	Activities Included

1. Monitor health status to identify and solve community health problems.	• Epidemiology and Surveillance Activities:
	  o Infectious disease
	  o Chronic disease
	  o Injury
	  o Behavioral risk factors
	  o Environmental health
	  o Syndromic surveillance
	  o Maternal and child health
	• Completion of community health assessment

2. Diagnose and investigate health problems and health hazards in the community.	• Screening for Diseases/Conditions
	  o HIV/AIDS
	  o Other STDs
	  o Tuberculosis
	  o Cancer
	  o Cardiovascular disease
	  o Diabetes
	  o High blood pressure
	  o Blood lead
	• Laboratory Services

3. Inform, educate, and empower people about health issues.	• Population-based Primary Prevention Activities
	  o Injury
	  o Unintended pregnancy
	  o Chronic disease
	  o Nutrition
	  o Physical Activity
	  o Violence
	  o Tobacco
	  o Substance Abuse
	  o Mental illness
	• Food safety education

4. Mobilize community partnerships and action to identify and solve health problems.	• Partnerships and Collaboration measured in the increasing levels of no programs, not involved, networking, coordinating, cooperating, and collaborating
	  o Emergency Preparedness
	  o Food Safety
	  o Maternal and child health
	  o Tobacco, alcohol or other drugs
	  o Community health assessment and planning

	○ Communicable/infectious disease ○ Chronic disease ○ Land use ○ Environmental health
5. Develop policies and plans that support individual and community health efforts.	• Local level policy making and advocacy ○ Prepared issue briefs for policy makers ○ Gave public testimony to policy makers ○ Participated on a board or advisory panel responsible for public health policy ○ Communicated with legislators, regulatory officials, or other policymakers regarding proposed legislation, regulations, or ordinances ○ Provided technical assistance to legislative, regulatory or advocacy group for drafting proposed legislation, regulations, or ordinances • New public health ordinance or regulation in past two years • Participated in developing a community health improvement plan • Developed agency wide strategic plan
6. Enforce laws and regulations that protect health and ensure safety.	• Regulation, inspection and/or licensing ○ Schools/daycare ○ Cosmetology business ○ Tobacco retailers ○ Smoke-free ordinances ○ Lead inspection ○ Public drinking water ○ Private drinking water ○ Food Service Establishments ○ Health-related facilities • Environmental Health Activities ○ Indoor air quality ○ Groundwater protection ○ Surface water protection ○ Air pollution
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable.	• Adult immunization • Child immunization • Treatment for communicable disease ○ HIV/AIDS ○ Other STDs ○ Tuberculosis • Maternal Child Health ○ Family planning ○ Prenatal care

	○ Obstetric care ○ WIC ○ MCH home visit ○ EPSDT ○ Well child clinic • Other health services ○ Comprehensive primary care ○ Home health care ○ Oral health ○ Behavioral/mental health services ○ Substance abuse services • Emergency medical services • Outreach and enrollment for medical insurance • School-based clinics • School health
8. Assure competent public and personal health care workforce.	• Use of core competencies for: ○ Writing position descriptions ○ Conducting staff performance evaluations ○ Assessing staff training needs ○ Developing staff training plans
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.	• Level of quality improvement activities ○ No QI activities ○ Informal or ad-hoc QI ○ Formal QI in specific areas ○ Formal QI agency wide • Agency QI Council or other committee that coordinates QI efforts • Staff member with dedicated time as part of their job description to monitor IQ work throughout the agency • Agency-wide QI plan • Agency performance data is used on an ongoing basis to drive improvement efforts • Leadership dedicates resources (e.g., time, funding) to QI • QI is incorporated in employee job descriptions • QI is incorporated in employee performance appraisals • QI resources and training opportunities are offered to staff on an ongoing basis
10. Research for new insights and innovative solutions to health problems.	• Use of the Guide to Community Preventive Services to support or enhance decision making • Identified research topics relevant to public health practice

	• Developing or refining research plans and/or protocols for public health studies • Recruiting study sites and/or study participants • Collecting, exchanging, or reporting data for a study • Analyzing and interpreting study data and findings • Disseminating research findings to key stakeholders • Applying research findings to practices within your own organization • Helping other organizations apply research findings to practice

Chapter 3

Apples to Apples: Identifying Comparison Groups When Accessing Health Department Performance

3.1 Abstract

Objective: To compare county level percentile rankings on the outcomes of smoking, motor vehicle deaths, and obesity when ranked within sociodemographic peer clusters as compared to nationwide rankings.

Methods: Random Forest algorithms were used to identify the sociodemographic characteristics most predictive of the outcomes of interest. All 3,144 counties in the United States were then clustered based on these sociodemographic characteristics. County percentile rankings on the outcomes of interest were compared before and after clustering.

Results: We found distinct sociodemographic clusters throughout the United States, with many states consisting of several different cluster types. Individual county outcome percentile ranks often differed greatly before and after clustering, with some counties percentile ranks differing as much as 40 points when considered within their sociodemographic peer cluster as compared to nationwide. Hence, some counties that appear to be poor performers within their state are actually top performers when compared to areas with similar demographics, and vice-versa.

Conclusions: Comparing county health outcomes on a nationwide or statewide bases fails to take the sociodemographic context of the county into account. Clustering counties by sociodemographic factors related to the outcome of interest allows a look into other factors that may be shaping the prevalence of outcomes in a community. These groupings may also aid learning exchange by identifying counties confronting similar health problems due to their underlying demographics.

3.2 Introduction

In 2015, life expectancy in the United States declined for the first time in decades.[1] There has been much discussion about the underlying cause of this trend shift, but it is clear that, overall, Americans have stopped gaining health. In addition, there are great disparities in health outcomes across the United States, with individuals of high socioeconomic status (SES) continuing to have better health outcomes, including longer life expectancy, than those of low SES.[2,3] Unfortunately these gaps appear to be widening. When considered on a county level, those counties with the highest life expectancies have continued to gain over the past 25 years, while those counties with the lowest life expectancies experienced plateaus. [3,4]

Local health departments are on the front lines of this battle to improve health in the United States, often with few resources and little data to inform health departments on their performance.[5–7] Local health departments often look to metrics such as the Robert Wood Johnson County Health Rankings as a means to evaluate their performance in relation to their state peers.[8] However, these comparisons frequently reflect the underlying socioeconomic differences within a state. Comparisons of vastly different populations within a state may be of limited utility and can obscure net gains being made by health departments serving low SES populations. In some cases, health departments working with hard to serve populations may even be harmed in competitive funding situations. Population interventions are often specialized to the target population in order to improve effectiveness, therefore if a county ranking last in a state were to implement

all of the same interventions as the county that ranked first, it is not certain that the interventions would have the same success. [9]

There is a need for appropriate comparison groups that health departments can use, not only to benchmark themselves, but also as a forum for learning exchange. This is not a new concept, urban health departments have been reaching out to one another for years, the Big Cities Health Coalition being a prime example.[10] This group has a data platform for comparisons between the largest cities on key health indicators and provides case studies on the interventions urban local health departments have used to impact many of these indicators. However, this leaves a void for rural health departments, which often lack formal relationships across state lines, and have seen stagnating health improvement as compared to urban health departments.[11,12]

Here we create comparison groups for local health departments based on the sociodemographic makeup of the county populations and evaluate the distributions of important health behaviors within the comparison groups, focusing on the Centers for Disease Control and Prevention's (CDC) Winnable Battles.

3.3 Methods

3.3.1 Study Data

Our analysis utilized individual level data from the 2014 Behavioral Risk Factor Surveillance System (BRFSS) and county level data from the 2016 Robert Wood Johnson Foundation County Health Rankings dataset, with additional measures included from the U.S. Census Bureau's American Community Survey (Appendix 3A). [13–15]

3.3.2 Data Analysis

To evaluate local public health performance in this study, we chose to focus on the CDC's Winnable Battles, which are priorities with large-scale health impacts and known effective strategies to address them.[16] Specifically, we evaluated county level smoking prevalence, obesity prevalence, and the rate of motor vehicle crash mortality across the United States as the outcomes of interest.

To identify the individual characteristics that were most predictive of outcomes of interest, we used the random forest algorithm to rank the importance of variables present in BRFSS data in predicting these outcomes.[17,18] Self-reported seatbelt use and driving under the influence of alcohol were used to evaluate the individual characteristics most predictive of motor vehicle crash mortality, because these outcomes are on the causal pathway to motor vehicle crash death.[19] Variables whose removal led to a mean decrease in accuracy of 10 misclassifications or greater were considered to highly predictive on the outcomes of interest. These variables were individual race/ethnicity, educational attainment, age, marital status, employment status, sex, and health insurance status. Proxies for these variables that were available at the county level were used to create county clusters. These variables were percent non-Hispanic African American, percent non-Hispanic white, percent Hispanic, percent American Indian, percent Asian, percent with some college education, percent married, percent unemployed, percent female, and percent uninsured median age. Percent rural was also included in further analysis due to its relationships with the outcomes and potential impact on intervention effectiveness.

K-means analysis was used to identify clusters of counties with similar sociodemographic profiles. Gap statistics, Bayesian information criterion, and within group sums of squares were used to select the optimal number of clusters.[20–22] These methods supported from six to ten clusters, and we choose to base our analysis on the median number of eight clusters. The sociodemographic characteristics of each of the clusters were investigated and clusters were mapped for visualization of the location of the clusters across the United States.

Counties were first given overall percentile ranks for each outcome based on their current smoking prevalence, obesity prevalence, and motor vehicle death rates, compared with all other counties in the United States. Outcome percentile ranks were then calculated separately for each cluster, comparing a county's outcome prevalence only to other counties within its cluster. These cluster specific outcome percentiles were compared to the previous nationwide percentiles. These nationwide and cluster specific county percentiles were mapped to highlight the high and low percentile counties before and after clustering.[23] To further highlight the differences in the prevalence of the outcomes of interest cluster specific means, variances, and average percentile change after clustering were calculated for each outcome. Data were analyzed using R v3.2.2.[24]

3.4 Results

The sociodemographic characteristics of each cluster of counties can be found in Appendix 3B. The clusters vary markedly from one another, particularly in racial and ethnic breakdowns, socioeconomic markers, and how rural the county is. We assigned

each cluster a name that highlights the makeup of its population. The eight clusters identified were: (1) rural, high SES cluster; (2) semi-urban, high SES; (3) young, urban, mid/high SES; (4) mostly rural, mid SES; (5) rural, mid/low SES; (6) semi-urban, mid/low SES; (7) a semi-urban, Hispanic; and (8) rural, American Indian. Counties from the same cluster tended to group geographically (Figure 3.1) displays the locations of the clusters, which tend to cluster together geographically as well.

The prevalence of the outcomes varies significantly between clusters. The high SES, rural group has the lowest average percent of smokers at 15.9%, while the rural, American Indian group has the highest at 29.3% (Table 3.1). Motor vehicle death rates range from 12.2/100,000 population in the young, urban, mid/high SES group to 46.4/100,000 population in the rural, American Indian group. The young, urban, mid/high SES group also had the lowest obesity prevalence at 28.4%, while the semi-urban, mid/low SES group had the highest at 35.9.

Figure 3.1: Map of the Sociodemographic Based County Clusters

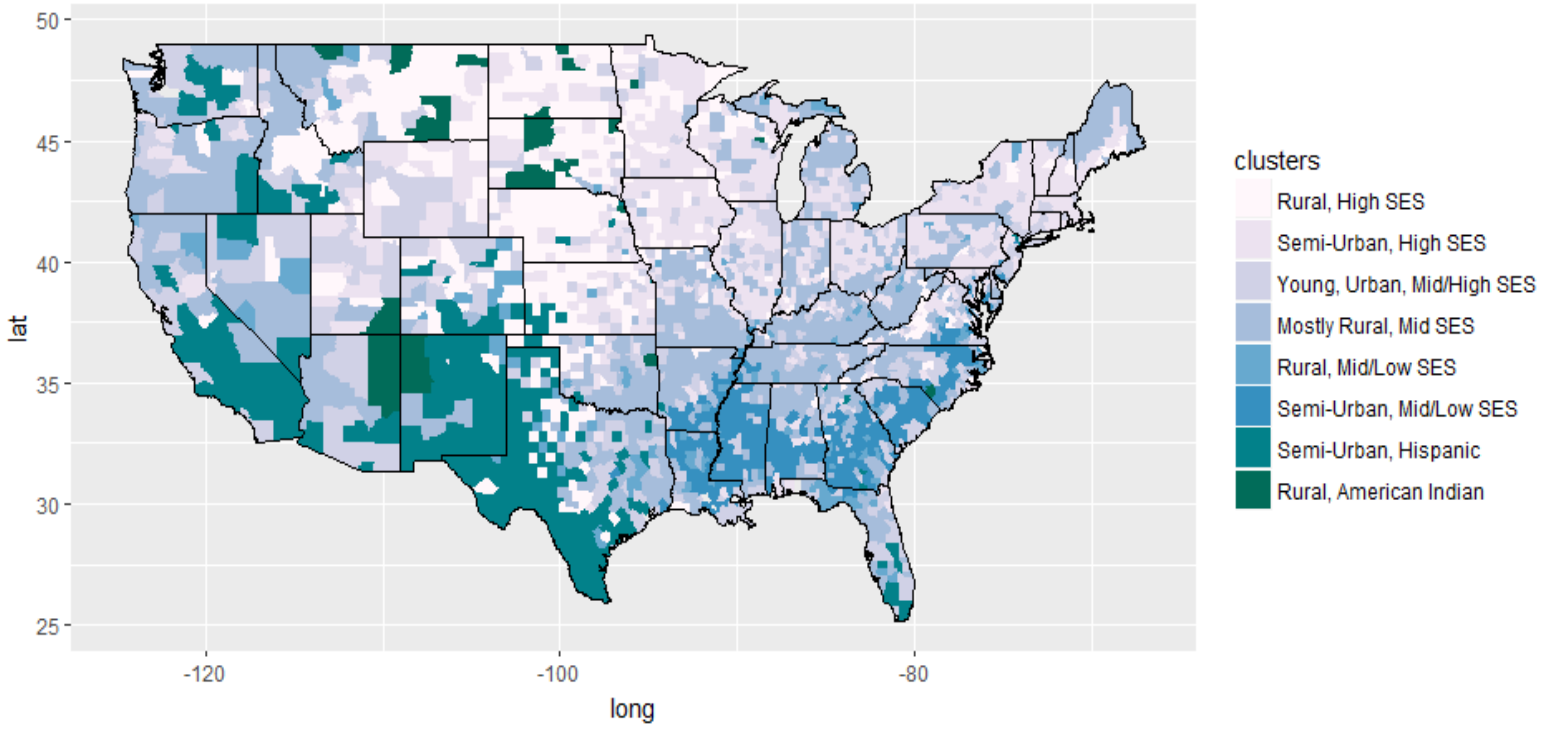


Table 3.1: Cluster Variance and Average Percentile Change for Each Cluster by Outcome

	Rural, High SES N=671	Semi-Urban, High SES n=727	Young, Urban, High/Mid SES n=37	Mostly Rural, Mid SES n=977	Rural, Mid/Low SES n=116	Semi-Urban, Mid/Low SES n=327	Semi-Urban Hispanic n=242	Rural, American Indian n=42	Overall
Smoking									
Average Percent Current Smokers	16.1	17.3	12.9	19.9	20.5	21.3	16.4	29.3	18.4
Cluster Standard Deviation	1.9	3.1	2.6	3.5	3.8	2.9	2.1	6.2	3.8
Average Percentile Change	19.8	7.6	38.9	-12.0	-17.6	-25.4	15.4	-43.7	-
Motor Vehicle Deaths									
Average Motor Vehicle Death Rate (per 100,000 population)	20.3	12.2	7.2	23.0	23.8	23.6	20.3	46.4	19.7
Cluster Standard Deviation	9.7	5.0	3.3	8.0	7.2	9.0	9.1	16.9	9.6
Average Percentile Change	-2.4	26.1	41.7	-12.8	-15.9	-13.0	-2.9	-39.8	-
Obesity									
Average Percent Obese	30.2	29.0	23.2	31.9	32.8	35.6	28.9	35.2	31.0
Cluster Standard Deviation	3.5	4.3	4.3	3.6	4.2	3.9	4.2	4.2	4.5
Average Percentile Change	6.2	12.9	35.0	-6.4	-11.6	-30.0	15.6	-28.9	-

By clustering the United States population into smaller, more homogenous groups, we would expect that within cluster standard deviations of the outcomes of interest might be smaller than the overall standard deviations in the outcomes of interest. This is what is typically seen with our clusters, however there are a few clusters with standard deviations that are larger than the overall standard deviation. The standard deviation is also interesting in this this analysis because it may serve as a metric to evaluate room for potential improvement, with health departments that are the bottom of a cluster with high variance having more room for improvement, whereas clusters with small variance may be hitting some improvement threshold. The percentage of current smokers within a county had an overall standard deviation of 3.8% and the cluster specific standard deviations ranged from 1.9% in the high SES, rural group, indicating very little outcome heterogeneity in that cluster, to 6.2% in the rural, American Indian group. Motor vehicle mortality had a standard deviation of 9.6 per 100,000 population, with cluster specific standard deviations ranging from 3.3 per 100,000 population in the young, urban, high/mid SES group to 16.9 per 100,000 in the rural American Indian group, indicating that there is a large range in the mortality caused by motor vehicles. Obesity had an overall standard deviation of 4.5%, and the cluster specific standard deviations ranged from 3.5% in the rural, high SES group to 4.3% in the young, urban, high/mid SES group, showing that counties within the same cluster tend to have similar obesity prevalence.

County percentile rankings often shifted dramatically when those percentiles were recalculated within the clusters (Figure 3.2). Across all outcomes, the overall percentiles tend to have strong regional tendencies, but there is more regional

heterogeneity introduced in the cluster specific percentiles. Additionally, clusters composed of mostly low percentile counties had an increase in their average percentile after clustering, because many of the counties within the clusters had an increased percentile when considered within the context of their cluster. Likewise, clusters composed of mostly high percentile counties tended to experience percentile decreases on average (Table 3.1).

As can be seen in Figure 3.2a and 3.2b, smoking tends to be concentrated in the Mississippi Valley and Appalachian Highlands regions of the United States. However, after clustering, much of the Southeast show improvements in their relative percentile, indicating that there are doing well compared to demographically similar counties; while some counties in the northern Midwest and Mountain regions have higher percentiles after clustering, suggesting that these counties have a high smoking prevalence compared to similar counties. Several counties in the rural, American Indian group had within cluster percentiles that were 70 points lower than their nationwide percentiles. For example, in Lyman County, South Dakota, 22% of the population are current smokers, placing the county in the 83rd percentile overall, however it is in the 8th percentile compared to the demographically similar counties in its cluster. This suggests that Lyman County may serve as an exemplar of best practices for smoking reduction in rural American Indian populations. Conversely, Sacramento County, California, has a smoking prevalence of 15%, placing it in the 16th percentile nationwide, but in the 78th percentile within its cluster. This suggests, that while Sacramento County has a relatively low smoking prevalence compared to the nation as a whole, its smoking control programs

have not been less successful compared to others in the young, urban, mid/high SES group.

Figure 3.2: Map of Overall and Cluster Adjusted Outcome Percentiles by County

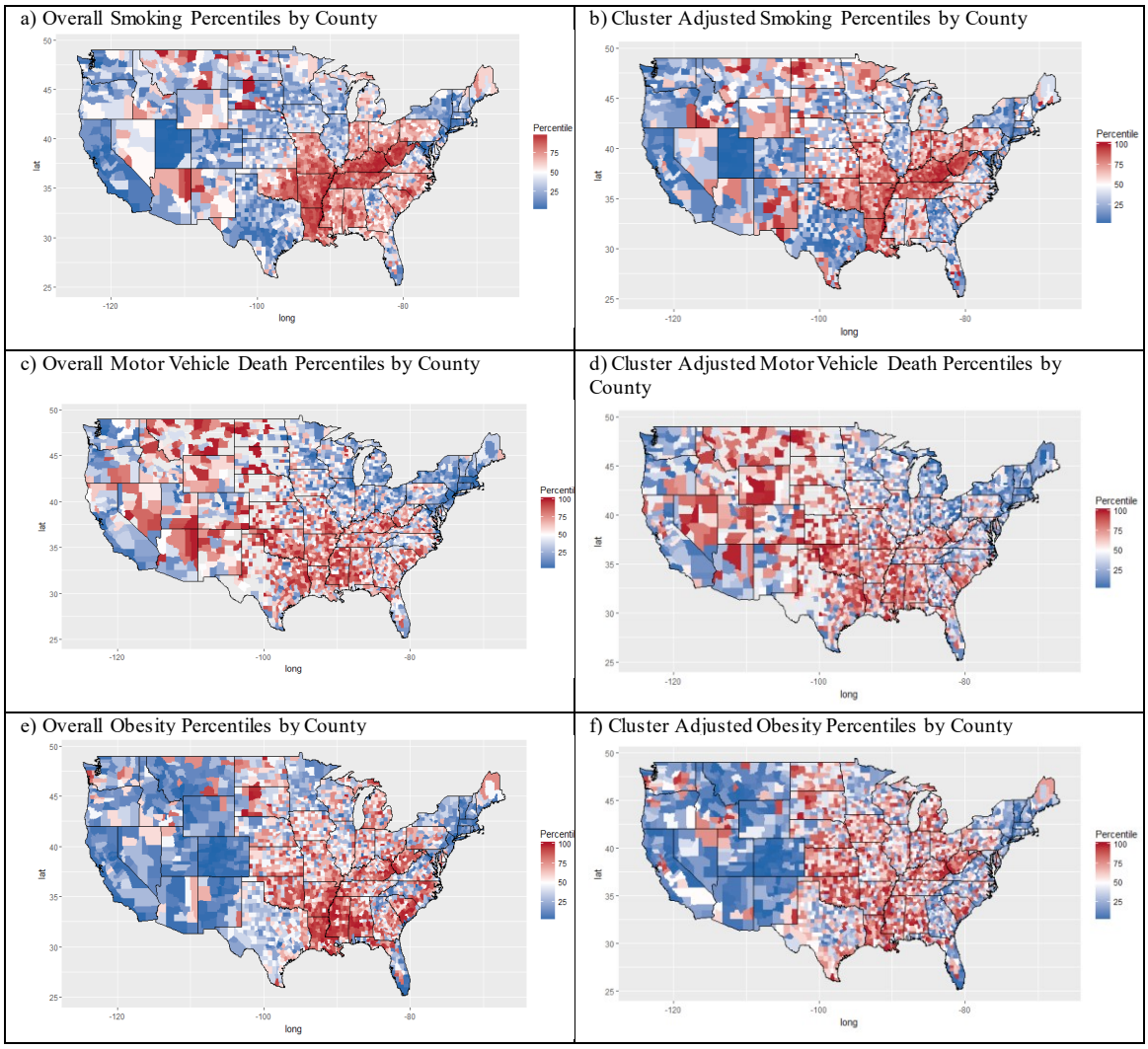


Figure 3.2c and 3.2d show that motor vehicle death rates are the highest in the most rural, central regions of the United States, where driving distances tend to be longer. This pattern is sustained after cluster specific percentiles are calculated, however there are notable changes for individual counties. This outcome also had many counties within the rural, American Indian cluster that had within cluster percentiles more than 70 points lower than their nationwide percentiles. Cibola County, New Mexico had the largest difference. With a motor vehicle death rate of 27/100,000 population the county was in the 80th percentile nationwide, however when considered within its cluster, it falls within the 8th percentile. The young, urban, high/mid SES group had very low rates of motor vehicle deaths overall, thus high performing counties show room for improvement compared to their cluster peers. For example, San Joaquin County, California has a motor vehicle death rate of 12/100,000 population, placing it in the 21st percentile overall, but within its cluster it is in the 92nd percentile.

The highest obesity percentiles are concentrated in the Southeast and Appalachian Highlands regions (Figure 3.2e). However, after clustering the highest percentiles are no longer as thickly concentrated in these regions, and again show up much more frequently in the Midwest (Figure 3.2f). One regional high performer is Houston County, Alabama, which has an obesity prevalence of 34%, placing it in the 77th percentile nationwide, but within the semi-urban, mid/low SES cluster it is in the 30th percentile. The young, urban, mid/high SES group had the lowest average obesity prevalence of any cluster, and within this group Sutter County, California has an obesity prevalence of 28% placing it in the 21st percentile overall, but within its cluster it is in the 90th percentile.

3.5 Discussion

This method demonstrates that there are clear sociodemographic clusters of counties throughout the United States and these clusters differ from one another in the prevalence of the three outcomes considered in this analysis. Although the clusters did have regional tendencies, states had counties from multiple different clusters within their borders. This suggests that comparisons within states may not be the best way to approach rankings, and that counties may share more similarities with counties outside of their states. Additionally, because the clustering in this paper is based on sociodemographic indicators that are predictive of the outcomes of interest, one might hypothesize that members of a given cluster would benefit from similar public health interventions, making these clusters excellent groups for learning exchange. Finally, when counties (and thus health departments) are evaluated within states, it often removes the national context from the ratings. For example, if your county is ranked first in your state based on health outcomes, but your state has some of the worst health outcomes in the country, it is unclear how meaningful a high ranking truly is.

The clusters differed from one another in the average prevalence of the outcomes of interest, and the cluster variances tended to be smaller than the overall variance. This indicates that cluster members tended to have similar outcome prevalence. Because of this, county percentiles within a given cluster would often shift as a whole when clustering was considered. However, the overall shifting of percentile ranks within a cluster, compared with the percentile ranks of other clusters, is a side effect, and not the point of this method. Instead, the aim is to look within clusters to highlight high and low performers within a given sociodemographic context.

This method provides a tool for comparing county performance to other counties with similar populations. Those counties with the highest percentiles overall, will continue to have the highest percentiles within their clusters, likewise those with the lowest percentiles overall, will continue to have the lowest percentiles within their clusters. However, those counties that have moderate performance on a nationwide scale, but are in a high performing cluster, will have high within cluster percentiles, as was seen in Sacramento County, California, San Joaquin County, California, and Sutton County, California. These high within cluster percentiles indicate that, although they may be doing well in the context of the entire United States, other counties with similar sociodemographic make ups tend to have better performance, which signals an opportunity for further improvement in these counties. Additionally, counties with moderate performance that belong to low performing clusters, had low within cluster percentiles as was seen in Lyman County, South Dakota, Cibola County, New Mexico, and Houston County, Alabama. These low within cluster percentiles suggest that although these counties have significant room for improvement in the national context, they are doing well for their respective groupings and should serve as examples for other counties in their clusters of how to make meaningful improvements.

The sociodemographic indicators that were predictive of the outcomes of interest had substantial overlap, allowing us to create a single clustering scheme that could be applied to all three outcomes. This suggest that this methodology could be applied to many other outcomes to obtain similar rankings and comparisons with little, if any, adjustment. This would enable local health departments to compare their performance to other counties within their cluster for any outcome for which there are data available.

Additionally, since these sociodemographic indicators upon which the clusters are based appear to be consistently important, local health departments could engage in learning exchange, even for those outcomes for which there is little data available in order to implement interventions that are likely to be the most effective within their populations. For this analysis we used a small number of clusters to make the clusters more digestible, however, BIC calculations suggested that using many more clusters would be almost equivalently acceptable. Hence, if health departments desire smaller, and more similar comparison groups, simply increasing the number of clusters in this analysis would be a reasonable way to achieve this goal.

The importance of the social inequities of health cannot be overemphasized, and evaluations that highlight these detrimental health gaps are vitally important, but the social inequities are often barriers that few local health departments have the resources to impact, particularly those health departments that have the worst health outcomes overall. This method provides a mechanism to create valuable comparison groups, through which the lowest performers within a cluster can gain valuable information on how to improve their performance by implementing similar interventions as the highest performers in the cluster. This is not to say that counties that perform well for their given clusters should consider their work done. These high performing counties should be looking to new and innovative ways to continue to improve the health of their populations and close the health gap caused by social inequities.

Beyond the social inequities of health there are other additional reasons why within state comparisons are logical and needed. Counties within a given state are subject to the same state legislation and are served by the same state health department, making

differences within a state a meaningful tool, particularly for state level decision making. Therefore, this method should be considered a supplementation to and not a replacement of current ranking methods.

Data availability was a limitation in this study, one that is frequently faced by local health departments searching for stable and comparable county level data. In order to obtain stable county level estimates, we often had to combine data for multiple years, meaning that county estimates may not be representative of the current outcome prevalence within a county. This would be particularly important for counties that have experience recent, rapid health improvements or declines within their populations.

3.6 Public Health Implications

Health inequalities in the United States are large, and continue to grow. Health departments require tools to fully assess their own performance, and the opportunity to share knowledge with health departments serving similar populations, and facing similar obstacles. This paper suggests a method for creating appropriate risk sets with which health departments can continue to monitor and improve the health of their populations.

References

1. Xu, JQ; Murphy, SL; Kochanek, KD; Arias E. *Mortality in the United States, 2015. NCHS Data Brief, No 267*. Hyattsville, MD; 2016.
2. Chetty R, Stepner M, Abraham S, et al. The Association Between Income and Life Expectancy in the United States, 2001-2014. *Jama*. 2016;315(16):1750-1766. doi:10.1001/jama.2016.4226.
3. Dwyer-Lindgren L, Bertozzi-Villa A, RW S, et al. Inequalities in life expectancy among us counties, 1980 to 2014: Temporal trends and key drivers. *JAMA Intern Med*. May 2017. http://dx.doi.org/10.1001/jamainternmed.2017.0918.
4. Wang H, Schumacher AE, Levitz CE, Mokdad AH, Murray CJ. Left behind: widening disparities for males and females in US county life expectancy, 1985-2010. *Popul Health Metr*. 2013;11(1):8. doi:10.1186/1478-7954-11-8.
5. Beitsch LM, Brooks RG, Menachemi N, Libbey PM. Public health at center stage: New roles, old props. *Health Aff*. 2006;25(4):911-922. doi:10.1377/hlthaff.25.4.911.
6. Castrucci BC, Rhoades EK, Leider JP, Hearne S. What Gets Measured Gets Done. *J Public Heal Manag Pract*. 2015;21:S38-S48. doi:10.1097/PHH.0000000000000169.
7. Frieden TR. Asleep at the switch: local public health and chronic disease. *Am J Public Heal*. 2004;94(12):2059-2061.
8. Robert Wood Johnson Foundation. County Health Rankings & Roadmaps. http://www.countyhealthrankings.org/. Published 2017. Accessed February 27, 2017.

9. Frohlich KL, Potvin L. Transcending the known in public health practice: The inequality paradox: The population approach and vulnerable populations. *Am J Public Health*. 2008;98(2):216-221. doi:10.2105/AJPH.2007.114777.

10. Big Cities Health Coalition. http://www.bigcitieshealth.org/. Accessed February 27, 2017.

11. University of Wisconsin Population Health Institute. *County Health Rankings Key Findings 2016*.

12. Harris JK, Beatty K, Leider JP, Knudson A, Anderson BL, Meit M. The Double Disparity Facing Rural Local Health Departments. *Annu Rev Public Heal*. 2016;37. doi:10.1146/annurev-publhealth-031914-122755.

13. University of Wisconsin Population Health Institute. *County Health Rankings Key Findings*.; 2016.

14. U.S. Census Bureau. *2010-2014 American Community Survey 5-Year Estimates*.

15. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Data*. Atlanta, Georgia; 2014.

16. Centers for Disease Control and Prevention. Winnable Battles. https://www.cdc.gov/winnablebattles/. Accessed February 28, 2017.

17. Breiman L. Random Forests. *Mach Learn*. 2001;45(1):5-32. doi:10.1023/A:1010933404324.

18. Liaw, A. and Wiener M. Classification and Regression by randomForest. *R News*. 2(3):18-22.

19. National Highway Traffic Safety Administration (NHTSA). Traffic Safety Facts: 2014. *US Dep Transp*. 2014;(March):U.S. Department of Transportation.

doi:http://dx.doi.org/10.1016/j.annemergmed.2013.12.004.

20. Milligan GW, Cooper MC. An examination of procedures for determining the number of clusters in a data set. *Psychometrika*. 1985;50(2):159-179. doi:10.1007/BF02294245.

21. Tibshirani R, Walther G, Hastie T. Estimating the number of clusters in a data set via the gap statistic. *J R Stat Soc Ser B (Statistical Methodol*. 2001;63(2):411-423. doi:10.1111/1467-9868.00293.

22. Fraley C, Raftery AE. How Many Clusters? Which Clustering Method? Answers Via Model-Based Cluster Analysis. *Comput J*. 1998;41(8):578-588. doi:10.1093/comjnl/41.8.578.

23. Kahle D, Wickham H. ggmap: Spatial Visualization with ggplot2. *R J*. 2013;5(1):144-161. doi:10.1023/A:1009843930701.

24. Team Rs. RStudio: Integrated Development for R. RStudio, Inc. 2016. http://www.rstudio.com/.

Appendix 3A: Sources of County Level Data

Measure	Source	Year(s)
Percent of adult population that are current smokers	Behavioral Risk Factor Surveillance System	2014
Motor vehicle crash death rate per 100,000 population	CDC WONDER Mortality Data	2007-2013
Percent of adult population with BMI ≥ 30	CDC Diabetes Interactive Atlas	2012
Percent of population under age 65 without health insurance	Small Area Health Insurance Estimates	2013
Percent of population aged 16 or greater that are unemployed but seeking work	Bureau of Labor Statistics	2014
Percent of adults aged 25 to 44 with some post-secondary education	American Community Survey	2010-2014
Percent of population that identify as non-Hispanic African American	Census Population Estimates	2014
Percent of population that identify as American Indian and Alaskan Native	Census Population Estimates	2014
Percent of population that identify as Hispanic	Census Population Estimates	2014
Percent of population that identify as Non-Hispanic white	Census Population Estimates	2014
Percent of population that are females	Census Population Estimates	2014
Percent of county that is considered rural	Census Population Estimates	2010
Median Age	American Community Survey	2010-2014
Percent of adult population that are married	American Community Survey	2010-2014

Appendix 3B: Cluster Sociodemographic Characteristics

Clusters	Rural, High SES N=671	Semi-Urban, High SES n=727	Young, Urban, High/Mid SES n=37	Mostly Rural, Mid SES n=977	Rural, Mid/Low SES n=116	Semi-Urban, Mid/Low SES n=327	Semi-Urban Hispanic n=242	Rural, American Indian n=42
Total Population	12,661,364	152,194,298	44,405,450	33,726,783	1,904,737	26,581,542	46,524,801	857,992
Percent White	92.1	70.7	42.2	86.4	67.5	49.9	45.2	30.6
Percent Hispanic	3.9	7.7	21.0	5.2	10.5	4.4	46.9	5.2
Percent African American	1.1	7.1	8.9	4.7	18.2	42.9	4.3	1.1
Percent Asian	0.6	2.5	20.77	0.6	0.7	1.0	1.7	0
Percent American Indian	1.3	1.2	2.2	1.7	2.0	0.7	2.1	59.6
Percent Some College	64.0	66.0	68.9	49.6	39.8	49.3	48.7	50.1
Percent Married	59.0	50.5	49.3	53.7	44.1	42.7	50.1	41.3
Percent Unemployed	4.5	5.4	5.8	7.2	6.8	8.7	6.0	9.5
Percent Female	49.8	50.5	49.6	50.2	42.2	51.3	49.3	49.0
Percent Uninsured	14.3	13.9	16.0	19.2	20.0	19.6	25.1	23.9
Percent Rural	79.9	25.1	10.5	73.0	75.3	56.4	40.3	83.1
Median Age	44.4	37.4	37.0	43.1	40.1	38.6	36.2	31.7

Chapter 4

How Health Departments Make an Impact: The Effects of Local Health Department Performance on the Ten Essential Public Health Services

4.1 Abstract

Objectives: To evaluate the associations between local health department characteristics, including performance scores on the Ten Essential Public Health Services, and health outcomes and behaviors in the populations they serve.

Methods: Multilevel logistic regressions were used to explore the associations between health department characteristics and the outcomes of general health rating, current smoking status, seatbelt use, and obesity, while controlling for individual level confounders.

Results: Higher Essential Public Health Service scores were significantly associated with decreased odds of poor general health, smoking, and inconsistent seatbelt use. Health department governance structure also had strong significant associations with health outcomes.

Conclusions: Our results suggest that local health departments have meaningful impacts on the health of the populations that they serve. Increased emphasis on building Essential Public Health Service Capacity and understanding the impact of health department

governance structure may aide health departments in further improving the health of their populations.

4.1 Introduction

In recent years, the United States has seen a decline population health. The country's average life expectancy decreased in 2015, and over the next few decades' is expected to fall even further behind other industrialized countries.[1,2] However, life expectancy is not homogenous across the United States. At the county level, there are large inequalities in life expectancy that are often associated with income or other socioeconomic status markers.[3,4] Additionally, these gaps appear to be widening as those counties with the longest life expectancy continue to improve, while those with the shortest life expectancies have seen stagnating improvements.[5] Local health departments provide a prime avenue by which to reach underserved populations, however the populations with the worst health outcomes, tend to also have local health departments with the fewest resources.[6–9]

There is growing evidence that local health department capacity may have a meaningful impact on the populations being served with studies showing that increased health department resources and activities are associated with reductions in measures of morbidity and mortality.[8,10–13] However, the authors of this work are careful to state that an influx in funding alone will not likely cause measurable improvements, but the funding must bring about improvements in public health practice. Other work has shown that decreases in local health department spending are associated with a reduction on performance on the Ten Essential Public Health Services (EPHS), suggesting that local health department fulfillment of these services lies on the causal pathway of the

relationship between health department resources and morbidity and mortality in the population.[14]

At a time when many local health departments are facing workforce and funding cuts, tough decisions must be made about which programs and activities should remain a priority, which may lead to a specialization of local health departments that we are already seeing some evidence of.[15–17] Evidence that not only demonstrates that local health departments' performance on the EPHSs is associated with the health of the populations served, but also states specifically which services have the strongest associations with population outcomes, would be invaluable to local health departments prioritizing where limited resources should be placed.

In this study we investigate if local health department characteristics, including performance on the EPHSs, are associated with reductions in poor health outcomes or behaviors. Specifically, we focus on outcomes that are part of the Centers for Disease Control and Prevention's (CDC) Winnable Battles. These are outcomes selected because they cause high morbidity and mortality, but have known effective prevention strategies.[18]

4.2 Methods

Local health department data were drawn from the National Association of City and County Health Officer's 2013 National Profile of Local Health Departments.[19] The derivation of local health department performance scores on the ten essential public health services is described in previous work.[17] The questionnaire was completed, and scores were calculated, for 2,000 of 2,532 (79%) local health departments. Scores were

derived from questions in both the core questionnaire and supplemental modules. The supplemental modules were not completed by all local health departments. In order to retain the most local health departments in our data set, only EPHS scores derived from the core questionnaire will be used in this analysis. These essential services include:

EPHS 1. Monitor health status to identify and solve community health problems
EPHS 2. Diagnose and investigate health problems and health hazards in the community
EPHS 3. Inform, educate, and empower people about health issues
EPHS 5. Develop policies and plans that support individual and community health efforts
EPHS 6. Enforce laws and regulations that protect health and ensure safety
EPHS 7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable

Data on individual risk factors and outcomes was drawn from the 2014 SMART BRFSS dataset.[20] These data are a subset of the Behavioral Risk Factor Surveillance System (BRFSS) data and are comprised of those metropolitan and metropolitan statistical areas that have at least 500 completed BRFSS interviews.[21] The individual level BRFSS data was linked to the health department data by zip code. To account for zip codes often falling into multiple counties (the jurisdiction level of most local health departments) weighted bootstrapping was used to create random samples and models were run on 1000 iterations of these bootstrap derived samples.

Zip code matches to the SMART BRFSS data were made for 65.4% (1,308/2,000) of the local health departments with previously calculated EPHS performance scores, this

is 51.7% (1,308/ 2,532) of all local health departments in the United States. The final matched dataset contained data for 194,114 individuals from 46 states and Washington D.C. Rhode Island and Hawaii were not included in the analysis because they do not have local health departments, and Wyoming and New Hampshire were excluded due to low sample size.

As previously mentioned, the outcomes for this analysis were drawn from the CDC's Winnable Battles. Specifically, we focused on the areas of smoking, motor vehicle deaths and obesity. For the outcome of smoking we used individuals' self-reported current smoking status. To evaluate motor vehicle deaths, we used self-reported seatbelt use as the outcome of interest, categorized as "always use a seatbelt" vs "not always". The outcome of obesity was categorized as anyone with a self-reported BMI ≥ 30. We also investigated the outcome of general health, which was categorized as those that self-reported their general health as "excellent", "very good", or "good" versus those that reported their health as "fair" or "poor".

Multilevel logistic regressions were used to model the relationships between local health department scores and the outcomes described. A state level random effect was used to account for differences that may occur at the state level, such as differences in state health department capacity or differences in state public health legislation. Model 1 for each outcome is comprised of this random intercept only model.

Model 2 builds upon Model 1 by adding in individual level confounders. The included individual level covariates are age categorized as "18 to 34", "35 to 54", and "55 and older", education categorized as "some college or greater" vs "no college", employment categorized as "employed" vs "unemployed", which includes individuals

that are retired, marital status categorized as "married" or "unmarried", race categorized as "non-Hispanic white", "non-Hispanic black", and "other", and sex. As with Model 1, Model 2 is applied to each of the outcomes of interest.

Model 3 further builds upon the previous two models by adding in the local health department covariates. Model 3a includes adds in local health department scores for EPHS 1: Monitor Health Status, EPHS 2: Diagnose and Investigate, EPHS 3: Inform, Educate and Empower, EPHS 5: Develop Policy, EPHS 6: Enforce Laws and Regulations, and EPHS 7: Link to and Provide Care. Model 3b does not include EPHS scores, but adds other local health department characteristics, which were per capita health department expenditures, the size of the population served, the health department governance category, and the presence of the local board of health. Model 3c includes all covariates from Model 3a and 3b. All continuous variables were mean centered and scaled by standard deviation. Each of these models were run on 1000 iterations of weighted bootstrapped samples.

4.4 Results

The final merged data set was comprised of 194,114 individuals which were linked to 1,308 local health departments (Table 4.1). The individuals in the dataset tend to be older in age with 55.1% aged 55 or older. The sample is predominantly non-Hispanic White (77.4%) and is 41.8% male. The means and standard deviations of the EPHS scores for this sample are very similar to those of the full sample described in previous work. The local health departments in the sample were typically locally governed (68.1%) and most had oversight by a local board of health (68.7%).

Table 4.1: Sample Descriptors: Individual and Local Health Department Characteristics

Individual Characteristics N=194,020	
Age, *n* (%)	
18 to 34	29,483 (15.2)
35 to 54	57,535 (29.7)
55 and older	107,002 (55.1)
No college education, *n* (%)	61,502 (31.8)
Unemployed, *n* (%)	90,355 (46.8)
Unmarried, *n* (%)	90,355 (46.8)
Race, *n* (%)	
Non-Hispanic White	147,798 (77.4)
Non-Hispanic Black	20,118 (10.5)
Other	23,155 (12.1)
Male, *n* (%)	81,126 (41.8)
Health Department Characteristics N=1,305	
Mean Score, (SD)	
EPHS 1: Monitor Health Status	62.0 (26.4)
EPHS 2: Diagnose and Investigate	49.3 (29.6)
EPHS 3: Inform, Educate and Empower	45.1 (29.6)
EPHS 5: Develop Policy	56.7 (31.7)
EPHS 6: Enforce Laws and Regulations	43.3 (23.7)
EPHS 7: Link to and Provide Care	46.7 (29.9)
Mean per capita expenditures ($), (SD)	49.5 (75.3)
Mean population (in thousands), (SD)	190.1 (478.2)
Governance Category, *n* (%)	
Local	888 (68.0)
State	291 (22.3)
Shared	126 (9.7)
Has local board of health	884 (68.6)

For each of the outcomes, the models' AICs decreased for each additional set of covariates added, with Model 3c consistently having the lowest AIC for each outcome. When considering the outcome of general health, each of the individual level covariates were significantly associated with reporting poor or fair health, with older age, no college education, being unemployed, being unmarried, being a racial minority and being a male all increasing the odds of reporting poor or fair health (Table 4.2). The local health department's EPHS 4 (Diagnose and Investigate) score, also had a statistically significant relationship with an individual's health rating, with each standard deviation increase in EPHS 4 score the odds of an individual reporting poor or fair health increased by 6 percent (OR: 1.06; 95% CI: 1.02, 1.09). Increased local health department scores on EPHS 3 (Inform, Educate, and Empower) and EPHS 7 (Link to and Provide Care) were associated with decreases in the odds of reporting poor or fair health. With each standard deviation increase in EPHS 3 the odds of poor health decreased by 3 percent (OR: 0.97; 95% CI: 0.94, 0.99) and with each standard deviation increase in EPHS 7 the odds decreased by 4 percent (OR: 0.96; 95% CI: 0.93, 0.99). The health department governance structure also seemed to play an important role with those individuals living in the jurisdiction of a state governed local health department having 20 percent higher odds of reporting poor or fair health than individuals living in locally governed jurisdictions (OR: 1.21; 95% CI: 1.10, 1.33).

Table 4.2: Multilevel logistic regressions modeling the influence of individual characteristics and local health department characteristics on the odds of reporting fair or poor health

	Model 1	Model 2	Model 3a	Model 3b	Model 3c
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
AIC	174,518.1	151,236.0	98,522.6	121,389.1	80,405.0
Intercept	0.21 (0.20, 0.21)	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)	0.02 (0.02, 0.02)
Individual level					
Age (18 to 34)					
35 to 54		**2.53 (2.39, 2.67)**	**2.58 (2.42, 2.76)**	**2.51 (2.37, 2.67)**	**2.59 (2.41, 2.78)**
55 and older		**2.53 (2.41, 2.66)**	**2.59 (2.45, 2.75)**	**2.55 (2.42, 2.69)**	**2.62 (2.46, 2.80)**
Education (some college)					
No college		**2.13 (2.07, 2.18)**	**2.10 (2.04, 2.17)**	**2.12 (2.06, 2.18)**	**2.09 (2.02, 2.16)**
Employment (Employed)					
Unemployed		**3.26 (3.15, 3.37)**	**3.18 (3.06, 3.31)**	**3.22 (3.11, 3.33)**	**3.15 (3.01, 3.28)**
Marital status (married)					
Unmarried		**1.63 (1.59, 1.68)**	**1.61 (1.56, 1.66)**	**1.63 (1.58, 1.68)**	**1.61 (1.55, 1.67)**
Race (non-Hispanic white)					
Non-Hispanic black		**1.58 (1.52, 1.64)**	**1.61 (1.53, 1.69)**	**1.58 (1.51, 1.65)**	**1.60 (1.51, 1.69)**
Other		**1.88 (1.81, 1.95)**	**1.94 (1.85, 2.03)**	**1.93 (1.85, 2.01)**	**2.02 (1.92, 2.13)**
Sex (Female)					
Male		**1.17 (1.14, 1.20)**	**1.17 (1.13, 1.21)**	**1.15 (1.12, 1.18)**	**1.15 (1.11, 1.20)**
Health department level					
EPHS scores					
EPHS 1: Monitor Health Status			1.00 (0.97, 1.02)		0.98 (0.95, 1.00)
EPHS 2: Diagnose and Investigate			**1.04 (1.01, 1.07)**		**1.06 (1.02, 1.09)**
EPHS 3: Inform, Educate and Empower			0.98 (0.96, 1.01)		**0.97 (0.94, 0.99)**
EPHS 5: Develop Policy			1.00 (0.97, 1.02)		1.00 (0.98, 1.03)
EPHS 6: Enforce Laws and Regulations			1.00 (0.98, 1.02)		1.01 (0.98, 1.03)
EPHS 7: Link to and Provide Care			0.98 (0.95, 1.01)		**0.96 (0.93, 0.99)**
Per capita expenditures				1.01 (0.99, 1.05)	1.04 (0.99, 1.09)
Population				1.00 (1.00, 1.01)	**1.01 (1.00, 1.02)**
Governance Category (local)					
State				**1.18 (1.09, 1.27)**	**1.21 (1.10, 1.33)**
Shared				0.98 (0.88, 1.08)	1.08 (0.99, 1.19)
Local board of health				1.04 (0.99, 1.09)	1.04 (0.98, 1.10)
State level random effect					
95% CI	(0.13, 0.34)	(0.01, 0.03)	(0.02, 0.03)	(0.01, 0.03)	(0.02, 0.03)

Many of the individual level covariates were also significantly associated with the odds of being a current smoker (Table 4.3). Being aged 35 to 54, having no college education, being unmarried, and being a male all increasing the odds of being a current smoker. Being aged 55 or older and being a racial/ethnic category other than non-Hispanic white or black both significantly decreased an individual's odds of being a current smoker. The local health department's EPHS 3 (Enform, Educate and Empower) score also had a statistically significant relationship with an individual's health rating, with each standard deviation increase in EPHS 3 score the odds of an individual living in that health department's jurisdiction being a current smoker decreased by 4 percent (OR:0.96; 95% CI: 0.94, 0.99). Higher EPHS 1 (Monitor Health Status) and EPHS 2 (Diagnose and Investigate) scores were significantly associated with a higher odds of smoking in Model 3a, however these findings were no longer significant in the larger Model 3c. Each standard deviation increase in per capita expenditures by health departments was associated with a 6% increase in the odds of smoking (OR: 1.06; 95%CI: 1.02, 1.11). Increased population size served by the local health department was associated with a decreased odds of smoking (OR: 0.98; 95% CI:0.97, 0.99). The local health department's governance category also had a significant relationship with current smoking. Having a local health department that was state governed increased an individual's odds of smoking by 28 percent as compared to locally governed local health departments (OR: 1.28; 95%CI: 1.14, 1.45). A shared governance structure had a protective effect in Model 3b, but this was no longer significant in the larger Model 3c.

Table 4.3: Multilevel logistic regressions modeling the influence of individual characteristics and local health department characteristics on the odds of current smoking

	Model 1	Model 2	Model 3a	Model 3b	Model 3c
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
AIC	152,101.5	140, 287.0	91,516.6	112,191.2	74,757.3
Intercept	0.17 (0.17, 0.17)	0.09 (0.09, 0.09)	0.09 (0.09, 0.10)	0.09 (0.08, 0.09)	0.09 (0.08, 0.10)
Individual level					
Age (18 to 34)					
35 to 54		**1.16 (1.11, 1.21)**	**1.19 (1.12, 1.25)**	**1.15 (1.10, 1.20)**	**1.17 (1.10, 1.24)**
55 and older		**0.60 (0.58, 0.63)**	**0.62 (0.58, 0.64)**	**0.61 (0.58, 0.64)**	**0.61 (0.58, 0.65)**
Education (some college)					
No college		**2.24 (2.19, 2.31)**	**2.23 (2.15, 2.31)**	**2.26 (2.20, 2.33)**	**2.24 (2.15, 2.33)**
Employment (employed)					
Unemployed		**1.07 (1.03, 1.10)**	**1.04 (1.00, 1.08)**	**1.05 (1.01, 1.09)**	1.03 (0.98, 1.07)
Marital status (Married)					
Unmarried		**2.10 (2.03, 2.16)**	**2.13 (2.05, 2.21)**	**2.11 (2.04, 2.18)**	**2.13 (2.04, 2.21)**
Race (non-Hispanic White)					
Non-Hispanic Black		1.02 (0.97, 1.07)	1.01 (0.96, 1.07)	1.02 (0.96, 1.07)	1.01 (0.94, 1.07)
Other		**0.81 (0.77, 0.85)**	**0.79 (0.75, 0.84)**	**0.79 (0.75, 0.84)**	**0.77 (0.72, 0.83)**
Sex (female)					
Male		**1.32 (1.29, 1.36)**	**1.32 (1.28, 1.37)**	**1.30 (1.26, 1.35)**	**1.29 (1.24, 1.35)**
Health department level					
EPHS scores					
EPHS 1: Monitor Health Status			**1.02 (1.00, 1.05)**		1.00 (0.98, 1.03)
EPHS 2: Diagnose and Investigate			**1.03 (1.00, 1.06)**		1.02 (0.99, 1.06)
EPHS 3: Inform, Educate and Empower			**0.95 (0.93, 0.98)**		**0.96 (0.94, 0.99)**
EPHS 5: Develop Policy			0.98 (0.96, 1.01)		1.00 (0.96, 1.03)
EPHS 6: Enforce Laws and Regulations			0.99 (0.97, 1.01)		1.02 (0.99, 1.05)
EPHS 7: Link to and Provide Care			1.00 (0.97, 1.03)		0.99 (0.95, 1.02)
Per capita expenditures				**1.05 (1.02, 1.08)**	**1.06 (1.02, 1.11)**
Population				**0.99 (0.98, 1.00)**	**0.98 (0.97, 0.99)**
Governance Category (local)					
State				**1.34 (1.22, 1.47)**	**1.28 (1.14, 1.45)**
Shared				**0.80 (0.70, 0.91)**	0.92 (0.81, 1.03)
Local board of health				1.03 (0.98, 1.09)	0.99 (0.93, 1.06)
State level random effect					
95% CI	(0.11, 0.27)	(0.06, 0.14)	(0.06, 0.13)	(0.06, 0.14)	(0.06, 0.13)

The individual level covariates that had significant positive associations with inconsistent seatbelt use were no college education, being unmarried, being non-Hispanic black and being a male (Table 4.4). Increased aged, being unemployed, and being a racial/ethnic category other than non-Hispanic white or black all significantly decreased an individual's odds of inconsistent seatbelt use. The local health department's EPHS 1 (Monitor Health Status) and EPHS 6 (Enforce Laws and Regulations) scores also had statistically significant relationships with seatbelt use. With each standard deviation increase in EPHS 1 score the odds of an individual living in that health department's jurisdiction having inconsistent seatbelt use decreased by 5 percent (OR: 0.95; 95% CI: 0.92, 0.98) and each standard deviation increase in EPHS 6 score was associated with an 11 percent reduction in odds (OR:0.89; 95%CI: 0.85, 0.91). Increased per capita spending by the local health department was associated with an increased odds of inconsistent seat belt use (OR: 1.10; 95% CI: 1.04, 1.17). Having a local health department with shared state and local governance decreased an individual's odds of inconsistent seatbelt use by 29 percent as compared to locally governed local health departments (OR: 0.71; 95%CI 0.55, 0.95). State governance increased the odds of inconsistent seatbelt use in Model 3b, but this finding was no longer significant in the larger Model 3c.

Table 4.4: Multilevel logistic regressions modeling the influence of individual characteristics and local health department characteristics on the odds of inconsistent seatbelt use

	Model 1	Model 2	Model 3a	Model 3b	Model 3c
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
	129,496.7	122,191.5	79,188.7	99,141.1	65,448.6
Intercept	0.12 (0.12, 0.12)	0.10 (0.10, 0.11)	0.10 (0.10, 0.11)	0.09 (0.09, 0.10)	0.10 (0.09, 0.12)
Individual level					
Age (18 to 34)					
35 to 54		**0.69 (0.66, 0.72)**	**0.68 (0.64, 0.72)**	**0.68 (0.65, 0.72)**	**0.68 (0.64, 0.72)**
55 and older		**0.55 (0.53, 0.57)**	**0.55 (0.52, 0.58)**	**0.55 (0.53, 0.58)**	**0.55 (0.52, 0.58)**
Education (some college)					
No college		**1.41 (1.37, 1.46)**	**1.41 (1.35, 1.46)**	**1.42 (1.37, 1.47)**	**1.43 (1.37, 1.50)**
Employment (employed)					
Unemployed		**0.92 (0.89, 0.96)**	**0.90 (0.86, 0.94)**	**0.93 (0.89, 0.96)**	**0.90 (0.86, 0.95)**
Marital status (married)					
Unmarried		**1.40 (1.35, 1.44)**	**1.40 (1.35, 1.46)**	**1.38 (1.33, 1.43)**	**1.38 (1.32, 1.43)**
Race (non-Hispanic white)					
Non-Hispanic black		**1.17 (1.11, 1.24)**	**1.19 (1.11, 1.28)**	**1.21 (1.14, 1.28)**	**1.24 (1.15, 1.32)**
Other		**0.83 (0.79, 0.87)**	**0.87 (0.82, 0.92)**	**0.85 (0.80, 0.89)**	**0.88 (0.82, 0.94)**
Sex (female)					
Male		**2.00 (1.94, 2.06)**	**2.03 (1.96, 2.10)**	**1.94 (1.88, 2.01)**	**1.98 (1.90, 2.06)**
Health department level					
EPHS scores					
EPHS 1: Monitor Health Status			0.97 (0.95, 1.00)		**0.95 (0.92, 0.99)**
EPHS 2: Diagnose and Investigate			1.00 (0.97, 1.04)		1.01 (0.97, 1.04)
EPHS 3: Inform, Educate and Empower			1.02 (0.99, 1.05)		1.03 (0.99, 1.07)
EPHS 5: Develop Policy			1.02 (0.99, 1.06)		1.03 (0.98, 1.07)
EPHS 6: Enforce Laws and Regulations			**0.90 (0.88, 0.93)**		**0.88 (0.85, 0.91)**
EPHS 7: Link to and Provide Care			1.02 (0.99, 1.06)		0.99 (0.94, 1.03)
Per capita expenditures				**1.07 (1.02, 1.11)**	**1.10 (1.04, 1.17)**
Population				0.99 (0.98, 1.00)	1.00 (0.99, 1.01)
Governance Category (local)					
State				**1.26 (1.13, 1.42)**	0.93 (0.81, 1.09)
Shared				**0.77 (0.61, 0.95)**	**0.71 (0.57, 0.91)**
Local board of health				**1.10 (1.04, 1.17)**	1.05 (0.97, 1.13)
State level random effect					
95% CI	(0.05, 0.32)	(0.04, 0.27)	(0.03, 0.29)	(0.06, 0.14)	(0.07, 0.15)

Almost all of the individual level covariates had positive significant associations with obesity (Table 4.5). Being older aged, having no college education, being unmarried, being a race or ethnicity other than white and being a male all significantly increased the odds of obesity. Each standard deviation increase in the population size served by the health department was associated with a slight decrease in the odds of being obese (OR: 0.99; 95% CI: 0.98, 0.99). Having a local health department that was state governed was associated with an 18 percent increase in an individual's odds of obesity as compared to locally governed local health departments (OR: 1.18; 95% CI: 1.09, 1.28). None of the EPHS scores had significant associations with an individual's odds of being obese.

Table 4.5: Multilevel logistic regressions modeling the influence of individual characteristics and local health department characteristics on the odds of obesity

	Model 1	Model 2	Model 3a	Model 3b	Model 3c
	OR (90% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
AIC	221,813.4	214,457.1	136,053.8	171,794.1	111,692.7
Intercept	0.40 (0.40, 0.40)	0.21 (0.20, 0.22)	0.22 (0.21, 0.23)	0.20 (0.19, 0.21)	0.21 (0.19, 0.22)
Individual level					
Age (18 to 34)					
35 to 54		**1.75 (1.69, 1.81)**	**1.76 (1.68, 1.84)**	**1.74 (1.68, 1.81)**	**1.76 (1.67, 1.85)**
55 and older		**1.55 (1.49, 1.60)**	**1.54 (1.48, 1.62)**	**1.55 (1.49, 1.61)**	**1.55 (1.47, 1.62)**
Education (some college)					
No college		**1.27 (1.24, 1.29)**	**1.26 (1.22, 1.29)**	**1.28 (1.25, 1.31)**	**1.26 (1.22, 1.30)**
Employment (employed)					
Unemployed		1.01 (0.98, 1.03)	1.01 (0.98, 1.04)	1.01 (0.98, 1.04)	1.02 (0.99, 1.05)
Marital status (married)					
Unmarried		**1.05 (1.03, 1.07)**	**1.03 (1.00, 1.06)**	**1.05 (1.02, 1.08)**	**1.04 (1.01, 1.07)**
Race (non-Hispanic white)					
Non-Hispanic black		**1.88 (1.81, 1.94)**	**1.85 (1.77, 1.92)**	**1.90 (1.83, 1.97)**	**1.88 (1.79, 1.96)**
Other		**1.12 (1.08, 1.16)**	**1.16 (1.11, 1.21)**	**1.13 (1.09, 1.17)**	**1.16 (1.10, 1.21)**
Sex (female)					
Male		**1.08 (1.06, 1.11)**	**1.08 (1.05, 1.11)**	**1.07 (1.05, 1.10)**	**1.08 (1.05, 1.12)**
Health department level					
EPHS scores					
EPHS 1: Monitor Health Status			1.00 (0.99, 1.02)		1.00 (0.98, 1.02)
EPHS 2: Diagnose and Investigate			0.99 (0.97, 1.01)		0.99 (0.97, 1.02)
EPHS 3: Inform, Educate and Empower			0.99 (0.97, 1.01)		0.98 (0.96, 1.00)
EPHS 5: Develop Policy			0.99 (0.97, 1.01)		1.01 (0.98, 1.03)
EPHS 6: Enforce Laws and Regulations			1.00 (0.98, 1.02)		1.02 (1.00, 1.05)
EPHS 7: Link to and Provide Care			1.02 (0.99, 1.04)		1.02 (0.99, 1.05)
Per capita expenditures				0.98 (0.95, 1.00)	0.97 (0.94, 1.01)
Population				**0.99 (0.98, 0.99)**	**0.99 (0.98, 0.99)**
Governance Category (local)					
State				**1.18 (1.10, 1.27)**	**1.18 (1.09, 1.28)**
Shared				0.99 (0.91, 1.08)	1.04 (0.95, 1.14)
Local board of health				1.04 (1.00, 1.08)	1.02 (0.98, 1.07)
State level random effect					
95% CI	(0.29, 0.55)	(0.16, .0.29)	(0.16, 0.29)	(0.15, 0.27)	(0.16, 0.28)

4.5 Discussion

This study attempts to address two important questions. First, do health department activities and characteristics impact the prevalence of outcomes in the communities served in measurable ways, and second, are there particular EPHSs that seem to be of particular importance for addressing health outcomes? This study has shown that there are statistically significant relationships between the characteristics of local health departments and the outcomes in the populations they serve, supporting previous findings.[10–13] However, in contrast to past studies, population size, and per capita expenditures were less important than the health departments' governance structures with individuals living in the jurisdictions of state governed local health departments tending to have higher odds of poor health outcomes or behaviors. The strength and consistency of the associations between state governed local health departments and poor health outcomes and behaviors is remarkable and warrants further investigation.

Local health department EPHS scores also had significant associations with individual health outcomes. Health departments with higher scores on EPHS 3 (Inform and Educate) were associated with lower odds of smoking in the individuals served. This finding is logical, because population based prevention activities fall within this EPHS, suggesting that health department prevention services are truly impacting their populations. The odds of inconsistent seat belt use were negatively associated with health department scores on EPHS 1 (Monitor Health Status) and EPHS 6 (Enforce Laws and Regulations), with the EPHS 6 association being the strongest of any of the score relationships. This relationship is less clear cut, as we wouldn't expect health departments

to be enforcing seatbelt laws, however it may be indicative of a culture in which health departments work closely with other agencies such as law enforcement. Interestingly, those individuals living in jurisdictions with higher scores on EPHS 2 (Diagnose and Investigate) tended to report worse general health, though this may be explained by access to diagnostics leading to a better understanding of their true health condition.

Although the EPHS score associations all had small effect sizes, when considered on the population level, these small difference can have large effects on health. Therefore, these findings serve to underscore the importance of local health department functions. None of the EPHS scores were consistently associated with improved health outcomes, with different outcomes having different EPHSs associated with them. This implies that particular services may be more or less important for a given health outcome the health department is attempting to address, but that no essential service stands out as being the most consistently needed. This may indicate that well rounded health departments, which have strong capacity in each of the essential service areas are likely the most effective when considering the overall health of the populations served. Our analysis also suggests that there may be some mediation occurring between the health department characteristics, such as the governance category, and the essential public health scores. This would be an interesting relationship for further exploration as it will likely provide further insight on the mechanisms by which health departments impact their populations.

This study does have some limitations that should be noted when considering the results. We were unable to evaluate the outcomes of all ten of the EPHS, due to a reduced sample size when using the full group, however by investigating six of the ten we gain

valuable insight on the overall importance of these services and underscore the need for further research in this area. Additionally, the EPHS were based only on the activities the health departments reported participating in, with no measure of how well these activities were performed. It would be expected that there would be substantial variation in performance even among health departments with similar scores. There is also the potential for reverse causation, particularly with indicators such as per capita expenditures. Finally, we have no data on the interaction of the individuals with their health departments. We are assuming that these individuals gain some benefit from being in the jurisdiction of their local health department, but have no data to support a causal link.

4.6 Public Health Significance

Local health departments are an often overlooked piece of the United States public health infrastructure, but they are well placed to impact some of the most vulnerable populations. This study supports the idea that high performance local health departments can have meaningful impacts on the populations they serve and provides evidence that the Essential Public Health Services are meaningful metrics that local health departments should build their services around.

References

1. Xu, JQ; Murphy, SL; Kochanek, KD; Arias E. *Mortality in the United States, 2015. NCHS Data Brief, No 267*. Hyattsville, MD; 2016.

2. Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. *Lancet*. 2017;389(10076):1323-1335. doi:10.1016/S0140-6736(16)32381-9.

3. Dwyer-Lindgren L, Bertozzi-Villa A, RW S, al et. Inequalities in life expectancy among us counties, 1980 to 2014: Temporal trends and key drivers. *JAMA Intern Med*. May 2017. http://dx.doi.org/10.1001/jamainternmed.2017.0918.

4. Chetty R, Stepner M, Abraham S, et al. The Association Between Income and Life Expectancy in the United States, 2001-2014. *Jama*. 2016;315(16):1750-1766. doi:10.1001/jama.2016.4226.

5. Wang H, Schumacher AE, Levitz CE, Mokdad AH, Murray CJ. Left behind: widening disparities for males and females in US county life expectancy, 1985-2010. *Popul Health Metr*. 2013;11(1):8. doi:10.1186/1478-7954-11-8.

6. Harris JK, Beatty K, Leider JP, Knudson A, Anderson BL, Meit M. The Double Disparity Facing Rural Local Health Departments. *Annu Rev Public Heal*. 2016;37:167-184. doi:10.1146/annurev-publhealth-031914-122755.

7. Berkowitz B. Rural public health service delivery: Promising new directions. *Am J Public Health*. 2004;94(10):1678-1681. doi:10.2105/AJPH.94.10.1678.

8. Erwin PC. The performance of local health departments: a review of the literature. *J Public Heal Manag Pr*. 2008;14(2):E9-18. doi:10.1097/01.phh.0000311903.34067.89.

9. Institute of Medicine Committee on Assuring the Health of the Public in the 21st Century. *The Future of the Public's Health in the 21st Century*.; 2002. doi:10.17226/10548.

10. Erwin PC, Greene SB, Mays GP, Ricketts TC, Davis M V. 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. doi:10.2105/AJPH.2009.177451.

11. Verma R, Clark S, Leider J, Bishai D. Impact of State Public Health Spending on Disease Incidence in the United States from 1980 to 2009. *Health Serv Res*. 2016;(Astho):1-15. doi:10.1111/1475-6773.12480.

12. Mays GP, Smith SA. Evidence links increases in public health spending to declines in preventable deaths. *Health Aff*. 2011;30(8):1585-1593. doi:10.1377/hlthaff.2011.0196.

13. Schenck AP, Meyer AM, Kuo TM, Cilenti D. Building the evidence for decision-making: The relationship between local public health capacity and community mortality. *Am J Public Health*. 2015;105:S211-S216. doi:10.2105/AJPH.2014.302500.

14. Mays GP, McHugh MC, Shim K, et al. Getting what you pay for: public health spending and the performance of essential public health services. *J Public Health*

Manag Pract. 2004;10(5):435-443. http://www.ncbi.nlm.nih.gov/pubmed/15552769.

15. National Association of City and County Health Officials. *The Changing Public Health Landscape: Findings from the 2015 Forces of Change Survey*. Washington, DC; 2015. http://nacchoprofilestudy.org/wp-content/uploads/2015/04/2015-Forces-of-Change-Slidedoc-Final.pdf.

16. Bekemeier B, Pantazis A, Dunbar MD, Herting JR. Classifying Local Health Departments on the Basis of the Constellation of Services They Provide. *Am J Public Health*. 2014;104(12):e77-e82. doi:10.2105/AJPH.2014.302281.

17. Wallace M, Sharfstein J, Lessler J. *What Do Local Health Departments Do? Performance and Approaches to Essential Public Health Services.*; 2017.

18. Centers for Disease Control and Prevention. Winnable Battles. https://www.cdc.gov/winnablebattles/. Accessed February 28, 2017.

19. National Association of City and County Health Officials. *2013 National Profile of Local Health Departments*. Washington, DC; 2014. WWW.nacchoprofilestudy.org.

20. Centers for Disease Control and Prevention (CDC). SMART: BRFSS City and County Data and Documentation. https://www.cdc.gov/brfss/smart/Smart_data.htm. Published 2014. Accessed June 15, 2016.

21. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor*

Surveillance System Survey Data. Atlanta, Georgia; 2014.

Chapter 5

Conclusions

Throughout the process of writing this dissertation, the need for robust public health practice in the United States has been continuously reaffirmed. The much publicized drop in life expectancy in 2015 sparked conversations about what circumstances led to the United States having some of the worst health metrics among industrialized nations.[1] Recent international infectious disease outbreaks such as the Ebola and Zika outbreaks have challenged the front lines of public health and brought forward questions about our ability to coordinate responses.[2,3] The prevalence of chronic disease continues to rise and the overdose epidemic continues to surpass expectations.[4,5] These health challenges are paired with government debate on the fate of the Affordable Care Act, which threatens to leave even more people without access to healthcare.

For the United States to make meaningful improvements on the health of the population, governmental public health agencies, including local health departments, must be engaged in the process. This means these agencies must have the resources and capacity to perform all of the services that are required of them and there must be an understanding of what activities are most important for them to perform. This dissertation attempts to answer these questions, and highlight the importance of local public health practice in the United States public health infrastructure.

In Chapter 2 we found that there is a significant amount of variability in local health department performance on the Ten Essential Public Health Services, and there are many health departments that perform few of the activities that were categorized into the services. Areas that health departments tended to perform particularly poorly in included "Assurance of a Competent Health Workforce" and "Performance of Public Health Research". The Essential Public Health Service scores were significantly associated with the size of the populations that the health departments served and their per capita funding. We also found that there are distinct essential service score based health department clusters. The health departments in these clusters differed from each other in two distinct ways. First, there were three apparent performance tiers, with low, mid, and high performing health departments being separated by their overall performance. Second, within each tier, health departments were further divided based their focus area, which feel into the categories of "policy and regulation" or "direct patient services".

In Chapter 3 we wanted to investigate the method of comparing health departments based on their sociodemographic characteristics, instead of within states or across the nation. We found that health department performance rank on outcomes shifts considerably when they are compared to similar peers, as compared to a nationwide ranking. These peer-to-peer comparisons may provide health departments with a more equitable way of evaluating their own performance, and would provide health departments with more logical peer groups for learning exchange.

In Chapter 4 we found that while individual level covariates have the largest overall impact on an individual's odds of poor health outcomes or behaviors, many health department characteristics also had significant associations with the odds of health

outcomes. Health department scores on the Essential Public Health Services were shown to significantly decrease the odds of poor health outcomes and behaviors. Perhaps the most surprising finding in this chapter was the strong and consistent relationship between the local health department governance structure and health outcomes, with individuals living in the jurisdictions of state governed local health departments having higher odds of poor health outcomes and behaviors.

In this dissertation, we set out to describe the current level of local health department performance on the Ten Essential Public Health Services and investigate whether these metrics of performance are important for the outcomes in the communities they serve. We have demonstrated that there is great diversity in the level of activities being performed in local health departments and that there are several public health services in particular that tend to fall far short of expectations. Our findings also suggest that these essential services are important in improving health outcomes, and that local health departments may hold real potential to boost our nation's health status. However, there is little hope that there will be a large influx in resources granted to these institutions. Therefore, there is the continued need to do more with less. Perhaps with continued research, the specific minimum tasks that are required for the optimum performance can be further elucidated, and health departments can streamline their activities appropriately. Another option to combat a lack of health department capacity may be to combine smaller health departments, where each health department serves a minimum population size. A solution that is supported by the results of this work.

While we have made great strides in answering these questions, there are still many unanswered questions that are fertile ground for future research. Validation of the

methods used to create the Essential Public Health Service Scores, particularly of the activities categorized into each of the services should be performed. Longitudinal studies would further increase the certainty of the associations between health departments and their communities. Finally, as much of the research has shifted to looking at public health systems, it is important understand what roles are most vital for health departments to fill.

This work has underscored the importance of local health departments, and often undervalued and under discussed part of the public health infrastructure and I hope we have made the case that local health departments serve an important role in the health of the United States population. We must learn how to make the local health departments as effective as possible, and provide them with the resources in order to perform the needed activities. This dissertation highlights areas of particular need and it is my hope that policy makers take steps to strengthening this much needed part of our public health infrastructure.

References

1. Xu, JQ; Murphy, SL; Kochanek, KD; Arias E. *Mortality in the United States, 2015. NCHS Data Brief, No 267*. Hyattsville, MD; 2016.

2. Gostin LO, Hodge JG, Burris S. Is the United States Prepared for Ebola? *JAMA*. 2014;312(23):2497. doi:10.1001/jama.2014.15041.

3. Gostin LO, Hodge JG. Is the United States Prepared for a Major Zika Virus Outbreak? *JAMA*. 2016;315(22):2395. doi:10.1001/jama.2016.4919.

4. Centers for Disease Control and Prevention. Chronic Disease Prevention adn Health Promotion. https://www.cdc.gov/chronicdisease/overview/index.htm. Published 2017. Accessed July 3, 2017.

5. Rudd RA, Seth P, David F, Scholl L. Increases in Drug and Opioid-Involved Overdose Deaths - United States, 2010-2015. *MMWR Morb Mortal Wkly Rep*. 2016;65(5051):1445-1452. doi:10.15585/mmwr.mm655051e1.

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EDUCATION

Doctor of Public Health in Epidemiology **Expected 2017**

Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

Masters of Public Health **2012**

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Master's Thesis: The Association of Community Level Factors and Overweight and Obesity in Arkansas

Graduate Certificate in Public Health Leadership **2011**

University of North Carolina Gillings School of Global Public Health, Chapel Hill, NC

Bachelor of Science in Genetics **2009**

University of Georgia, Athens, GA

PROFESSIONAL EXPERIENCE

Arkansas Department of Health, Little Rock, AR

Healthcare-Associated Infections Program Director and Epidemiologist **2010 – 2013**

Collected and analyzed healthcare-associated infections data, which was utilized to inform program decisions on prevention collaboratives, trainings and policy change. Served as a liaison to stakeholders, hospitals, legislators, and the federal government for all state related healthcare-associated infections activities.

PROFESSIONAL AND PRACTICE ACTIVITIES

Central Baltimore Community Health Work Group **2017 – present**

As part of the Central Baltimore Partnership's 2017 CBP Comprehensive Equity Planning Process, this group provided input on guiding improvements to community health through targeted strategies and recommendations.

MACHO Epidemiology Online Forum **2015 – present**

Created and maintains an online forum designed to support the activities of local health departments. The resources provided include a mechanism for learning exchange among local health officers and the provision of epidemiologic support to local health officials.

Baltimore City Health Department Practicum **2014 – 2015**

Oversaw the planning and completion of the Baltimore City Community Health Survey. Finalized the survey questionnaire, performed quality control monitoring throughout the interview process, completed data analysis, and write a final report based on the survey findings. Also provided epidemiologic support and reviewed outgoing presentations and publications for the Baltimore City Health Department.

Surveillance and Outbreak Response Team – Student Director **2013 – present**

Provides surveillance and outbreak support to local public health departments. The support provided includes writing outbreak protocols, providing surge capacity for outbreak response, and surveillance reports.

Arkansas Department of Health Emergency Operations Center On-call Team **2011 – 2013**

Responded to the Arkansas Department of Health's emergency operation center's (EOC) emergency hotline. Spoke with concerned citizens that called the hotline and advised on public health crises in Arkansas. Manned the EOC during times of emergency.

Communicable Disease Outbreak Investigation Team **2012 – 2013**

Responded to outbreaks reported to the Arkansas Department of Health and worked with local public health officials to halt disease transmission. Performed epidemiologic investigations and provided feedback to those involved in the outbreak.

Nuclear One Radiologic Dose Assessment Team **2012 – 2013**

Utilized math modeling to plan for efficient evacuation and dose assessment of the communities surrounding Arkansas' nuclear power plant in the instance of a nuclear emergency. Performed frequent training and drills to prepare for such an emergency.

100 Years of Public Health in Arkansas, Planning Committee **2012 – 2013**

Planned and executed educational and public relations events throughout the year to commemorate 100 years of public health in Arkansas.

TEACHING EXPERIENCE

Epidemiologic Inference in Public Health I – Lead Teaching Assistant **2015 – 2016**

Advanced Topics on Control and Prevention of HIV/AIDS – Teaching Assistant **2015**

Epidemiology and Public Health Impact of HIV and AIDS – Teaching Assistant **2014**

Epidemiology and Natural History of Human Viral Infections – Teaching Assistant **2014**

Public Health Surveillance – Teaching Assistant

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HONORS AND AWARDS

Charlotte Silverman Scholarship, Johns Hopkins Department of Epidemiology **2016**

HRSA Trainee Fellowship **2015**

Abe Lillienfeld Scholarship, Johns Hopkins Department of Epidemiology **2015**

Sue Parker Award of Excellence, Arkansas Public Health Association **2013**

Deans Scholarship, Johns Hopkins Bloomberg School of Public Health **2011**

ADVISORY PANELS

National

HHS Region VI Healthcare-Associated Infections Workgroup **2010 – 2013**

State of Arkansas

Act 845 Legislative Advisory Committee on Healthcare-Associated Infections **2010 – 2013**

TargetZero Program Steering Committee **2011 – 2013**

ARbestHealth Care Advancement Allies **2012 – 2013**

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Doctoral Student Council **2016**

PROFESSIONAL ASSOCIATIONS

Arkansas Public Health Association **2010 – 2013**
Second-Vice President

Association of Professionals in Infection Control and Epidemiology **2011 – 2013**
Subject Matter Expert, Surveillance and Epidemiological Investigation

American Public Health Association **2012 – 2013**

Council of State and Territorial Epidemiologist **2012 – 2013**

Society for Healthcare Epidemiology for America **2012 – 2013**

INVITED PRESENTATIONS

National

1. 2012 Healthcare-Associated Infections Data Summit. Small Group Facilitator. Kansas City, MO. May 30, 2012.

State of Arkansas

1. 2013 APIC Arkansas Spring Conference. Working Together, Saving Lives, Reducing Costs, Little Rock, AR. April 12, 2013.
2. The 20th Annual Arkansas Foundation for Medical Care Quality Conference. The National Healthcare Safety Network: The Down and Dirty. Little Rock, AR. April 4, 2012.
3. ARbestHealth Regional Meetings. The State of the State. Jonesboro, Little Rock, and Fort Smith, AR. January 29-31, 2013.
4. 2012 APIC Arkansas Annual Conference, Healthcare-Associated Infections Data Reporting, Little Rock, AR. October 29, 2012.
5. ARbestHealth Regional Meetings. The State of the State. Camden, Little Rock, and Rogers, AR. September 11-13, 2012.
6. ARbestHealth Regional Meetings. Healthcare-associated infections small group facilitator. Fort Smith, Little Rock, and Batesville, AR. June 19-21, 2012.
7. The 19th Annual Arkansas Foundation for Medical Care Quality Conference. Healthcare Associated Infections: Data Analysis. Hot Springs, AR. April 18, 2012.
8. National Healthcare Safety Network Reporting Educational Event. Healthcare-Associated Infections Quarterly Report. Little Rock, AR. July 14, 2011

9. National Healthcare Safety Network Reporting Educational Event. Enrolling in NHSN and Conferring Rights. Little Rock, AR. July 14, 2011

PUBLIC HEALTH COMMUNICATIONS

Baltimore City Health Department. Baltimore Community Health Survey 2014: Summary Results Report, September 2015

Centers for Disease Control and Prevention. (2013). Platform to Build a State Healthcare-associated Infections (HAIs) Website. http://www.cdc.gov/hai/HHS-HAI-Toolkit/

Arkansas Department of Health Healthcare-associated Infections Program. (2012). *The Arkansas Department of Health Healthcare-Associated Infections Report.* http://www.healthy.arkansas.gov/programsServices/epidemiology/Documents/HAI/HAILegislativeReport.pdf

U.S. Department of Health and Human Services Region VI work group. (2012) HAI Web-Based Tool Kit. http://www.haitoolkit.dsfederal.com/

Arkansas Department of Health Healthcare-associated Infections Program. (2012). *Healthcare-associated infections (HAI).* http://www.healthy.arkansas.gov/programsServices/epidemiology/Pages/HAI.aspx

U.S. Department of Health and Human Services Region VI work group. (2011) *Region VI Healthcare-Associated Infections Project- Year 1*.

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Centers for Disease Control and Prevention. Multiple-Serotype Salmonella Outbreaks in Two State Prisons — Arkansas, 2014. MMWR. 63(08);169-173

Arkansas Department of Health Communicable Disease and Immunizations Section. (2012) *Cummins Prison Salmonella Outbreak*.

Arkansas Department of Health Communicable Disease and Immunizations Section. (2012) *Tucker Prison Salmonella Outbreak*