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EXAMINING THE ACTIVITIES, EFFECTIVENESS, AND CONTRIBUTION OF LOCAL HEALTH DEPARTMENTS USING A NATIONAL LONGITUDINAL SURVEY OF PUBLIC HEALTH SYSTEMS

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DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Public Health
at the University of Kentucky

By

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ABSTRACT OF DISSERTATION

EXAMINING THE ACTIVITIES, EFFECTIVENESS, AND CONTRIBUTION OF LOCAL HEALTH DEPARTMENTS USING A NATIONAL LONGITUDINAL SURVEY OF PUBLIC HEALTH SYSTEMS

Health services research and public health services and systems research in the past have contributed to a strong foundation of evidence-based progress in organizing, financing, and delivering medical care and public health strategies across the United States. The purpose of this dissertation was to examine disparities in public health systems and in the delivery of population health services in communities served by these systems using nationally representative data from the National Longitudinal Survey of Local Public Health Systems (1998, 2006, 2012, and 2014).

Data from the 1998 cohort of 497 local health jurisdictions serving at least 100,000 residents, and from the 2014 expanded cohort of 546 local health jurisdictions serving less than 100,000 residents were used to conduct three studies. The first study "Local Public Health Systems and the burden of major heart diseases: A longitudinal analysis using National Longitudinal Survey of Local Public Health System" shows that stroke related mortality rate decreases over time in communities with increasing number of recommended population health activities. The second study "Rural Urban Differences in Recommended Population Health Activities and Organization of Public Health Delivery System Capital" shows that the urban communities with a centralized jurisdiction enjoy a greater availability of population health activities and a greater likelihood of being in a comprehensive population health system capital than rural non-centralized communities. The third study "Can comprehensive public health system determine the overall perceived effectiveness of public health activities and health status of a community?" shows a gradient relationship between public health systems composition and the ratings of perceived overall community health status and perceived effectiveness of the population health activities in communities where the most favorable ratings were observed in communities with comprehensive public health systems in comparison to conventional and limited public health systems.

KEYWORDS: Population health activities, Multi-sectoral collaborations, Longitudinal analysis, geographical disparities, Instrumental variable analysis, Generalized Estimating Equation

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December 7th, 2016
Date

EXAMINING THE ACTIVITIES, EFFECTIVENESS, AND CONTRIBUTION OF LOCAL HEALTH DEPARTMENTS USING A NATIONAL LONGITUDINAL SURVEY OF PUBLIC HEALTH SYSTEMS

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To my Parents, who gave me love of life

To my wife, who gave me a reason to live

To my kids, who gave meaning to live a life with full of love

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INTRODUCTION

Public Health System:

Public Health Systems are defined as a group of entities that includes official government public health agencies, other public, private sector, and voluntary organizations that produce a significant impact on the health of public (Moulton, Halverson, Honore, & Berkowitz, 2004) by contributing to the delivery of essential population health services (Centers for Disease Control and Prevention (CDC), 2014). The Institute of Medicine's (IOM) "Future of Public's Health in the 21st century" has called for public health systems, competent public health workforces, and a fiscal accountability systems to ensure the constitutional responsibilities – general public welfare – by assuring the availability and quality of population health activities (Institute of Medicine, 2002). Health services research and public health services and systems research in the past have contributed to a strong foundation of evidence-based progress in organizing, financing, and delivering medical care and population health strategies across the United States. To build on this foundation, new evidence is required to align the delivery of medical and population health practices, and to assess its effectiveness to promote community well-being and resiliency, realize efficiencies in resource utilizations and reduce disparities in population health (Systems for Action National Program Office, 2015).

The “Future of Public Health”, a landmark report of IOM in 1988, initiated important changes in the US public health system by helping the population health communities to think strategically, plan collectively, and perform effectively (Institute of Medicine, 1988; Turnock, 2004; Turnock, Handler, & Miller, 1998). IOM described three public health core functions: Assessment, Policy Development, and Assurance, which were widely accepted within the population health communities (Scutchfield, Hiltabiddle, Rawding, & Violante, 1997).

In 2014, health care spending increased by 5.3 percent to reach $3.0 trillion (approximately 17.5% of its GDP), or $9.5 thousand per person in the United States (CMS, 2014), a country that by far exceeds health care spending as a share of its economy (OECD, 2014). In 2014, only 2.7% of the nation’s overall healthcare expenditure is spent on population health measures (Himmelstein & Woolhandler, 2016), despite 75% of the health care cost is accounted for chronic conditions (Institute of Medicine, 2012) which would otherwise would have been prevented by using population health interventions. Despite far more spending in health than any other developed nations in the Organization for Economic Cooperation and Development (OECD), the United States falls behind in health outcomes such as overall life expectancy, and the incidence of preventable diseases and injuries (Institute of Medicine, 2012). Inadequate investment in public health system and paucity in the studies related to strategies at system performance level has been attributed to the imbalance between spending and outcomes (Institute of Medicine, 2012). Arden Handler and his colleagues (Handler, Issel, & Turnock, 2001) proposed a conceptual framework to assess performance of

public health system using the five inter-related components of the framework: macro context, mission, structural capacity, processes, and outcomes (Figure 1.1).

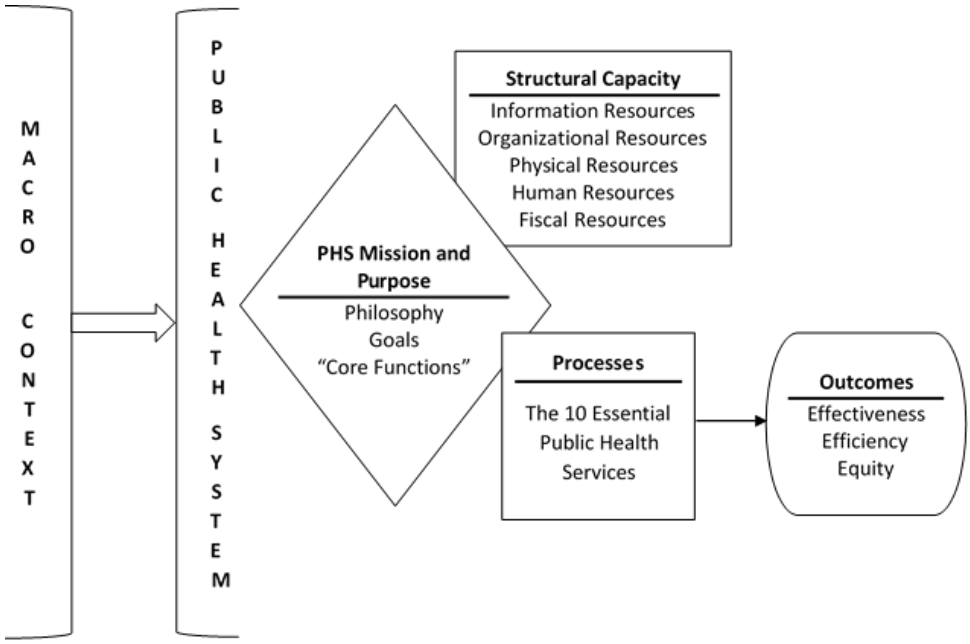

Figure 1.1: Conceptual framework of the public health system (PHS) as a basis for measuring system performance (adapted from, Handler et al., 2001).

Macro context: At supra-system, or macro level lies a system of elements that most closely interact with the public health systems. These elements that form the macro context include some major external interacting units such as social, political, and economic contexts operating in the whole society (e.g., the jurisdiction's economy, GDP, Gini coefficients, etc.); demand and need for public health based on a jurisdiction's indicators (e.g., mortality rates, socio-economic status, service utilization, or prevalence rates); social values and preferences for the public health products at a macro level (e.g. clean water, sanitation); and macro-level forces that lead public health systems to function in particular ways (e.g., the medical delivery system, technologic advances, the

nature of federal-state-local relationships, and the social, economic, cultural, health and environmental policies and conditions at the global, national, state, and local levels) (Handler et al., 2001; Shore, 2007).

Mission: The mission of the public health system consists of its time-specific goals and approaches to operationalize these goals. The mission is conceptualized as being carried out through the performance of the core public health functions: assessments, policy developments, and assurances, so as to ensure the conditions in which people can be healthy (Handler et al., 2001).

Structural Capacity: The collective resources related to informational, organizational, physical, human, and financial and their inter-relationships required to conduct system level processes forms the structural capacity component. For example, the NACCHO profile surveys provide useful information about the structural capacity of the public health systems (Handler et al., 2001).

Processes: Public Health can be practiced in terms of the key public health services referred to as the processes of the Public Health Systems. The key public health services can be regarded as partly cyclic from assessment to evaluation/research through community education and mobilization, policy development, law enforcement, and assurance of population health services (Handler et al., 2001). Historically, public health processes were assessed by measuring exposure to categorical interventions. However, using the essential public health framework, there have been several efforts to develop

generic measures of population health practices shifting from categorical interventions to the community and organization (Handler et al., 2001; Turnock et al., 1998) strengthening the governmental and non-governmental population health systems and enhancing multi-sectoral leadership and collaborations (Fielding, Teutsch, & Breslow, 2010).

Outcomes: The immediate and long-term changes experienced by individuals, families, communities, providers, and populations following the interaction between the population health interventions or processes and the structural capacity given the macro context and the system's mission and purpose are the system's outcomes (Handler et al., 2001). Outcomes are used to evaluate overall performances of the public health systems, including their efficiency, effectiveness, and ability to achieve an equitable population health characteristics. Linking these different outcome measures with structural capacities or processes of the public health systems will help to understand changes in population health status and this relationship would be regarded as superior to evaluating a specific population health program or intervention (Handler et al., 2001).

To enable these entities function independently and in partnership, public health infrastructure is necessary. Public health infrastructure is defined as the nerve center of public health systems constituting the resources and relationships such as the public health workforce, information and knowledge systems, organizational capacity (Centers for Disease Control and Prevention (U.S.) & United States, Congress, Senate, Committee on Appropriations, 2001; Turnock, 2004), and financial resources (Turnock, 2004) necessary to carry out the core functions and essential population health services.

For several years, the federal funding for public health has remained stagnant and at insufficient level, with remarkable budget cut at state and local health departments (Trust for America's Health, 2013). The need for multi-sectoral linkages to promote community development, human rights and security, and environmental protection has increased for the effectiveness and sustainability of health programs and policies (McMichael & Butler, 2006). New and resurging diseases, leadership deficits, and a persistent indigent care burden has put the nation's population health status in dismay (Institute of Medicine, 1988). Owing to these emerging health threats, and the trends in health care policy and health care market, there has been considerable focus on the performance of the nation's public health systems. The evidence based results from several studies (Mays, Halverson, Baker, Stevens, & Vann, 2004) motivated to implement population health initiatives, especially at the local jurisdiction as an essential component of public health infrastructure in most of the communities.

Based on a series of studies funded by the PHPPO (Public Health Practice Program Office) of the Centers for Disease Control and Prevention (CDC) in the US, 20 population health activities were identified to serve as indicators of local public health systems performance and each of the 20 activities were then linked to 1 of the 3 core public health functions (Figure 1.2) (Mays et al., 2004).

Assessment activities

1. In your jurisdiction, is there a community needs assessment process that systematically describes the prevailing health status in the community?
2. In the past 3 years in your jurisdiction, has the local public health agency surveyed the population for behavioral risk factors?
3. In your jurisdiction, are timely investigations of adverse health events conducted on an ongoing basis—including communicable disease outbreaks and environmental health hazards?
4. Are the necessary laboratory services available to the local public health agency to support investigations of adverse health events and meet routine diagnostic and surveillance needs?
5. In your jurisdiction, has an analysis been completed of the determinants of and contributing factors to priority health needs, the adequacy of existing health resources, and the population groups most affected?
6. In the past 3 years in your jurisdiction, has the local public health agency conducted an analysis of age-specific participation in preventive and screening services?

Policy development activities

7. In your jurisdiction, is there a network of support and communication relationships that includes health-related organizations, the media, and the general public?
8. In the past year in your jurisdiction, has there been a formal attempt by the local public health agency to inform elected officials about the potential public health impact of decisions under their consideration?
9. In your local public health agency, has there been a prioritization of the community health needs that have been identified from a community needs assessment?
10. In the past 3 years in your jurisdiction, has the local public health agency implemented community health initiatives consistent with established priorities?
11. In your jurisdiction, has a community health action plan been developed with community participation to address priority community health needs?
12. In the past 3 years in your jurisdiction, has the local public health agency developed plans to allocate resources in a manner consistent with community health action plans?

Assurance activities

13. In your jurisdiction, have resources been deployed as necessary to address priority health needs identified in a community health needs assessment?
14. In the past 3 years in your jurisdiction, has the local public health agency conducted an organizational self-assessment?
15. In your jurisdiction, are age-specific priority health needs effectively addressed through the provision of or linkage to appropriate services?
16. In your jurisdiction, have there been regular evaluations of the effects of public health services on community health status?
17. In the past 3 years in your jurisdiction, has the local public health agency used professionally recognized process and outcome measures to monitor programs and to redirect resources as appropriate?
18. In your jurisdiction, is the public regularly provided with information about current health status, health care needs, positive health behaviors, and health care policy issues?
19. In the past year in your jurisdiction, has the local public health agency provided reports to the media on a regular basis?
20. In the past 3 years in your jurisdiction, has there been an instance in which the local public health agency has failed to implement a mandated program or service?

Figure 1.2: Questions used to measure availability of Population Health Activities in the National Longitudinal Survey of Local Public Health Systems (Mays et al., 2004).

The U.S. national public health systems was not able to reach the proposed goal of 90% of the population served by a local health departments. Since 1993, researchers are assessing availability and adequacy of community level essential population health services and have generated ample evidence of gaps and variations in terms of performances. Only 50-56% of the identified essential population health activities were performed by local public health agencies (Richards et al., 1995; Turnock et al., 1994; Turnock et al., 1998). Only 22% of the local health departments (LHD) were effectively served, with an estimated 29% of the US population effectively served in 1995 (Turnock et al., 1998). Given a wide variation in organizational structure of public health delivery systems, Mays et. al. (Mays, Scutchfield, Bhandari, & Smith, 2010) identified seven distinct organizational configurations that can be grouped into three tiers of systems based on the differentiation defined by the scope of activities performed under the Assessment, Policy Development, and Assurance Domains of the Institute of Medicine's (IOM) core public health functions: Comprehensive; Conventional; and Limited Systems. Within these categories of the public health systems, 16% to 50% of the population were only served during 1998 through 2012 (Mays & Mamaril, 2015), which is still far below the US federal target.

National Longitudinal Survey of Local Public Health System (NLSPHS):

A survey of local health department directors in 1995 found agreement of the 20 activities which are indicators of local public health performance (Turnock et al., 1998). In 1998, a national longitudinal survey of local public health systems (Mays et al., 2004) (NLSPHS) was designed to follow a nationally representative cohort of U.S.

communities to examine the availability of population health activities, perceived effectiveness and local health department's contribution to each public health activity, and the type of organizations, other than local health department, that participated in performing each activity. These performance measures were developed in earlier studies of local health performance (Miller, Moore, Richards, & McKaig, 1994; Miller, Moore, Richards, & Monk, 1994; Miller et al., 1995). The instrument is regarded to have both content and criterion-related validity. The content validity was ensured by using expert panel processes, evidence reviews, case studies, and surveys. The population health activities assessed in NLSPHS were regarded as key services at the community level to protecting and promoting communities' population health status (Mays et al., 2010). Similarly, the criterion-related evidence has been shown in several studies using the constructs from NLSPHS to support predictive validity of the instrument. For example, composite measures from the survey instruments such as public health systems configurations has been used in predicting community level incidence of and/or mortality from communicable and chronic diseases (Mays, Mamaril, & Timsina, 2016; Rodriguez, Chen, Owusu-Edusei, Suh, & Bekemeier, 2012), hospital participation in population health activities (Hogg, Mays, & Mamaril, 2015), and multi-sector contributions in delivery of core population health activities (Sinclair & Whitford, 2015).

Each of the 20 population health activities used in NLSPHS can be grouped into one of the three core functions as defined by the Institute of Medicine (IOM): assessment (activities 1-6 in Figure 1.2); policy development (activities 7-12); and assurance (activities 13-20). The aggregate measure of availability indicated the proportion of 20 activities performed in the jurisdiction, whereas, the aggregate measure of perceived

effectiveness indicated the average effectiveness score assigned to activities performed in the jurisdiction. The aggregate measure of LHD's contribution indicated the average contribution score of the level of total community effort made by the jurisdiction in performing the public health activities (Mays et al., 2004).

Sampling:

The NLSPHS was launched to a cohort of jurisdictions serving at least 100,000 residents in 1998. This cohort of local health departments was identified from the national NACCHO profile survey of local health departments. The cohort of the jurisdictions who responded in 1998 was again surveyed in 2006 and 2012. In 2014, the original 1998 cohort was resurveyed. We referred to the original 1998 cohort as arm=1 in our data. The 2014 wave of the survey expanded the cohort to include a stratified random sample of public health agencies serving <100,000 residents, referred to as arm=3. The stratification for this small size jurisdiction was based on 4-category census region (northeast, Midwest, south, west), and 3-category population (<10k, 10k-49k, 50k-99k) producing 12 strata in sample. The sampling frame for the small size jurisdiction was obtained from the 2013 NACCHO profile survey. In this expanded cohort, we also included the small size jurisdictions that responded to the 2006 survey (n=45) and referred to them as arm=2. To avoid duplication in the sampling frame for arm=3, we excluded those who were included in arm=2 (Figure 1.3).

In stratified random sampling, we first divided the small size jurisdictions into subpopulations of 12 units (strata) such that N_L represents total population in stratum L, where $L = 1, 2, \dots, 12$ such that $\sum_{L=1}^{12} N_L = N$. Here $N =$ total population of small size

jurisdictions identified in 2013 NACCHO profile survey. Once the strata were identified, we did a simple random method to select a sample of LHDs from each stratum, without replacement. Let the sample sizes within the strata be denoted by $n_1, n_2, \ldots, n_L$.

We sampled 43 cases from each strata which were estimated to yield 30 cases per stratum at an average response rate of 70%, an expected response rate for the 2014 wave of the NLSPHS. We included all LHDs in our sample for those strata with less than 43 LHDs in the sampling frame.

Weights:

For weighting LHDs in Arm=3, we used following strategy: Let $\frac{n_L}{N_L} =$ selection probability for stratum, L. This ratio is also called sampling fraction. To get a response rate of 70% in general, we used $n_L = 43$ sample from each stratum. The inverse of the selection probability for an LHD in a stratum was obtained and was labelled as probability weight. Then we identified stratum in Arm=2 using the same strategy of stratification in Arm=3. We assigned the stratum specific probability weights for the LHDs from Arm=3 to LHDs in Arm=2.

In 1998, 100% of the LHDs serving at least 100,000 residents were sampled and therefore weights were not computed. However, since 1998 owing to the population growth, the number of large size jurisdiction grew. In 2013 NACCHO profile survey, there were 521 LHDs serving at least 100,000 population. Thus we created weights for the large size jurisdiction using analogous strategy used for small size jurisdiction:

1. Identified percentiles of the LHDs population for categories (<10,000; 10,000-49,999; and 50,000-99,999) in 2013 NACCHO profile survey.

2. Created a subset of LHDs serving at least 100,000 population and match merging it with the 1998 cohort of sample used in NLSPHS.
3. Generated population categories based on the percentiles obtained for small size jurisdictions in step 1.
4. Creating strata using the population category and the US census region for each large size jurisdiction.
5. Computed selection probability for each LHD, independently in each stratum using $\frac{n_L}{N_L}$.
6. Computing probability weights as the inverse of the selection probability.

Finally, adjusted weights were created for full NLSPHS data by normalizing each weights by its mean such that the mean of the adjusted weight for the full sample of NLSPHS was equal to 1. This adjusted weights was used to make national estimates from NLSPHS data.

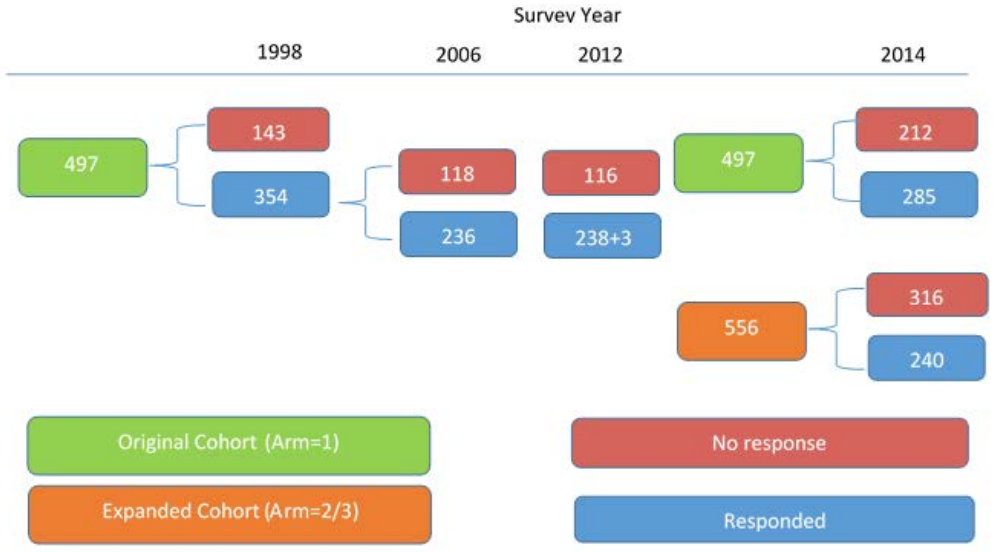

Figure 1.3: Schematic flow of survey sample by survey year with number of respondents and non-respondents

Response rates:

A total of 71% of the local health departments responded to the survey in 1998, 68% responded in 2006, 70% responded in 2012, and 57% responded in 2014. The response rate from small size jurisdiction in 2014 was 43%.

Strengths of NLSPHS:

In 2010, President Obama signed the Patient Protection and Affordable Care Act, commonly known as ACA, which was designed to realign and encourage collaboration between the public health and health care systems. ACA provisions were designed to expand insurance coverage, control costs, and target prevention to enhance access to health care and hence improve health outcomes of general people at population level. In addition to insurance reform initiatives, ACA also encouraged quality improvement, prevention, and public health initiatives making the governments responsible to uphold good quality in health-related goods and services under the right to health. The effects of these initiatives also may support greater availability and accessibility to health goods, particularly in the form of greater public health infrastructure and more affordable services (Gable, 2011).

The NLSPHS is the only national, longitudinal source of information about local public health systems and how they evolve and change over time. It provides an opportunity to examine the organization, financing, and delivery of public health services. In particular, we can compare how local public health systems are responding to the economic downturn and to the implementation of health systems reform under the Affordable Care Act.

Data Linkages:

NLSPHS uses study population from the NACCHO profile survey which gives us an opportunity to match merge it with NACCHO profile survey. A crosswalk was created to track the changes in NACCHOID across the four survey years of the profile survey: 1996/97, 2005, 2010, and 2013. We also merged the NLSPHS data with the GIS boundary files obtained from NACCHO using the NACCHOID to obtain county FIPS code that was used to match the NACCHO-NLSPHS linked data file with other sources of data that will be used in the study: Area Health Resource File, and Compressed Mortality Files from CDC - WONDER using
ICD-10 codes at county levels. The list of variables used in this dissertation and the source of data are listed in the Table 1.1.

Table 1.1: List of the variables and data source used in this dissertation

Variable	Available years	Source
Stroke (mortality rates per 100,000)	1999-2014	CDC-WONDER (Compressed Mortality File)
Alzheimer's Disease (mortality rates per 100,000)	1999-2014	CDC-WONDER (Compressed Mortality File)
Total availability	1998, 2006, 2012, 2014	NLSPHS
Total effectiveness	1998, 2006, 2012, 2014	NLSPHS
Total contribution	1998, 2006, 2012, 2014	NLSPHS
Public Health System Typology	1998, 2006, 2012, 2014	NLSPHS
Core functions of public health	1998, 2006, 2012, 2014	NLSPHS
Local board of health	1997, 2005, 2011, 2013	NACCHO
Population size(log)	1997, 2005, 2011, 2013	NACCHO
FTE (log)	1997, 2005, 2011, 2013	NACCHO
Type of PH governance	1997, 2005, 2011, 2013	NACCHO
Centralized	1997, 2005, 2011, 2013	NACCHO

Mixed/shared	1997, 2005, 2011, 2013	NACCHO
Percent at poverty level	1997-2012	AHRF
Percent non-white	1980, 1990, 2000, 2010	AHRF
Hospital beds/100,000	1998-2006, 2010, 2011	AHRF
Physicians/100,000	1998-2006, 2010, 2011	AHRF
Population density	2000, 2010	AHRF
Income per capita	1997-2012	AHRF
Percent 65+	1997-2012	AHRF
Unemployment rate 16+	1997-2013	AHRF

The chapters that follow present studies using different measures from NLSPHS to examine local trends in population health status and disparities in public health systems compositions, and the delivery of population health services in communities served by these systems using nationally representative data from the National Longitudinal Survey of Local Public Health Systems (1998, 2006, 2012, and 2014). The Chapter Two, "Local Public Health Systems and the burden of major heart diseases: A longitudinal analysis using National Longitudinal Survey of Local Public Health System" shows that stroke related mortality rate decreases over time in communities with increasing number of recommended population health activities. This study is consistent with studies that looks at association of multi-sector health planning and implementation activities with mortality from other chronic heart diseases and diabetes (Mays et al., 2016).

Results from Chapter Three, "Rural Urban Differences in Recommended Population Health Activities and Organization of Public Health Delivery System Capital" shows that the urban communities with a centralized jurisdiction enjoy a greater availability of population health activities and a greater likelihood of being in a comprehensive population health system capital than rural non-centralized communities. This is the first study to document rural-urban disparities in terms of recommended

population health activities and multi-sectoral community health planning, implementation, and community coalition using a nationally representative data in the US. This is also the first study to examine the difference in population health system capital between rural and urban geographic regions.

Chapter Four, “Can comprehensive public health system determine the overall perceived effectiveness of public health activities and health status of a community?” shows that there appears to be a dose-response relationship between public health system compositions: comprehensive vs conventional vs limited, and the ratings of perceived overall community health status and perceived effectiveness of the population health activities in communities. This is the first US study to examine how the perception of local health directors about the community health status is driven by the multisector health planning and implementation activities thus highlighting the importance of shared resources through multisector partnerships, particularly in communities where support is otherwise limited or unavailable.

CHAPTER TWO:
LOCAL PUBLIC HEALTH SYSTEMS AND THE BURDEN OF MAJOR HEART DISEASES: A LONGITUDINAL ANALYSIS USING NATIONAL LONGITUDINAL SURVEY OF LOCAL PUBLIC HEALTH SYSTEM

Background

The United States is continually facing the epidemic of major heart disease including strokes. One in every four deaths in the US is attributed to heart disease. Heart disease is the leading cause of death for both men and women in the US and more than half of the deaths due to heart disease in 2009 were in men (Centers for Disease Control and Prevention (CDC), 2015). Approximately, every 24 seconds, one US resident suffers a heart attack and each 1 minute 24 seconds, someone in the US dies from a heart disease-related event (Mozaffarian et al., 2016). Cardiovascular disease costs more than any other diagnostic groups. The estimated total annual costs, including direct costs and indirect costs from lost future productivity, for cardiovascular disease in 2012 was $316.6 billion (Mozaffarian et al., 2016).

Stroke, the fifth leading cause of mortality, is a condition with the second highest mortality rates from any cardiovascular diseases (Mendis, Puska, & Norrving, 2011) and is the major cause of serious long-term disability in US adults (Kochanek, Xu, Murphy, & Arias, 2014; Mozzafarian, Benjamin, Go, & et, 2015). Every year, stroke occurs in about 800,000 US adults with 600,000 incident cases, accounting for one death every 4 minutes, and costing the US an estimated $33 billion each year in direct and indirect cost (Mozzafarian et al., 2015).

There exists a wide racial/ethnic variability in the risk of having stroke and dying from it. Blacks have higher (Centers for Disease Control and Prevention (CDC), 2012a), generally double, the risk of getting first stroke and are more likely to die from it than the whites. The risk for stroke in Hispanics is greater than that in non-Hispanics (Mozzafarian et al., 2015). Though the risk for stroke increase by age, it can occur at any age. In 2009, 34% of the hospitalizations due to stroke were in people younger than 65 years (Hall, Levant, & DeFrances, 2012). About 49% of the Americans have major risk factors for the stroke- high blood pressure, high cholesterol, and smoking (Centers for Disease Control and Prevention (CDC), 2012b). Stroke hospitalization rates can be reduced by making healthy lifestyle choices and educating the population about the management of certain health conditions (Centers for Disease Control and Prevention (CDC), 2014) and the risk factors (Centers for Disease Control and Prevention (CDC), 2003).

With the increasing "baby boomers" population, the prevalence of heart disease is projected to increase 1.6% each year and the deaths due to major heart disease and stroke are expected to increase 2.5 times than that of the general population (Foot, Lewis, Pearson, & Beller, 2000). Age, racial and ethnic disparities in cardiovascular deaths remain persistently high in the United States. After controlling for all other risk factors in a Framingham Study, the older non-Hispanic Whites than non-Hispanic Blacks and Hispanics and younger non-Hispanic Blacks and Hispanics than non-Hispanic Whites were at higher risks for cardiovascular mortality (Hurley, Dickinson, Estacio, Steiner, & Havranek, 2010).

The United States experiences comparatively lower health status compared to its high-income Organization for Economic Cooperation and Development (OECD) "peer" countries in key areas: obesity, diabetes, heart disease, chronic lung disease, and disability. In 2013, the United States, despite its above-average mortality for ischemic heart disease, had the third lowest mortality rate from ischemic stroke among the peer countries (National Research Council (US), Institute of Medicine (US), 2013; OECD, 2015). Specifically, when compared to some of the high income countries, in the US, the older adults (50-54 years) reported to have significantly higher level of cardiovascular risk factors and hence a higher prevalence of heart disease, stroke, diabetes, hypertension, and obesity (National Research Council (US), Institute of Medicine (US), 2013). Similarly, the U.S. adults, 65 years and older were more likely to report having heart diseases than their Japanese counterparts (Reynolds et al., 2008).

Despite the magnitude of the problem, morbidity and mortality from major heart diseases are largely preventable. The economic burden of health can decline by nearly 17% i.e. about $149 billion by preventing cardiovascular diseases (Trogdon, Finkelstein, Nwaise, Tangka, & Orenstein, 2007). There have been significant improvements in treatment and prevention of heart disease and stroke in the United States. However, heart disease and stroke are still the leading causes of death and disability (Centers for Disease Control and Prevention (CDC), 2009). Population health approaches to address the cardiovascular health and healthy aging such as health promotion and risk reduction at midlife, early identification and treatment of cardiovascular conditions, integrated programs with system approach to address multiple comorbid conditions, clinical and community linkages, policy, system and environmental approaches promoting choices,

availability, accessibility, information, and resources for healthful behavior will benefit from a multilevel, multisector approach at the state and local level (Mays, Mamaril, & Timsina, 2016).

Different community level population health activities (Turnock et al., 1994) including regular community health needs (U.S. Centers for Disease Control and Prevention, 2013) and behavioral risk factors assessments with timely investigation of any adverse health events will ensure the capacity of a community to effectively target social, economic, and behavioral determinants of health through development of health promotion strategies, intervention programs, and health policies at the state, city, and county levels in the community (Chowdhury et al., 2016) over time. Moreover, access to population health activities can be ensured in a community by ensuring public health laboratory services for routine surveillance and diagnosis and by utilizing results obtained from analyzing determinants and contributing factors of cardiovascular disease so as to evaluate the priority health needs, the adequacy of existing health resources to address the burden and the cluster of population that is mostly affected in the community. For effective program intervention and policy strategies, public health agencies should analyze the utilization of preventive and screening services such as regular blood pressure checkups and cholesterol screenings (Pennant et al., 2010). Failure to intensify the utilization of the screening and preventive efforts now will abruptly increase the future burden and cost of cardiovascular disease (Centers for Disease Control and Prevention, 2014).

Multi-sectoral coalition and networks of organizations that connects priorities, capacities, and skills of various organizations and individuals is a useful policy strategy

to strengthen services and reduce the geographic and socioeconomic disparities in population health (Mays et al., 2016), particularly in non-communicable and chronic conditions (WHO, 2012). In addition, local health agencies can be effective advocates with elected officials and decision-makers by providing an avenue for holding government accountable for its commitment and priorities. In terms of improving chronic health conditions, the local health agencies can inform elected officials who could effectively influence (Shak, Swartz, & Rivera, 2013) the design of the community, including walking paths, biking trails, playgrounds, access to healthy foods, and promote smoke free communities can have a sustainable impact on reduction of morbidity and mortality from cardiovascular diseases (CCLHO-CHEAC, 2013).

Given the resource limitation but greater community demands of population health services to address socially and economically burdensome health conditions, the public health agencies need to prioritize the health problems and the associated risk factors, identify priority stakeholders and partners to focus on prevention and control efforts using cost effective health initiatives. There are several examples of major and small-scale cardiovascular prevention initiatives including initiatives involving linkage to primary care that appear promising in risk reductions (Karwalajtys & Kaczorowski, 2010). Ensuring active community participation in health planning, and resource allocation and deployment planning will help to maximize the capacity of a cardiovascular program in a community. The health resource allocation and deployment decisions are generally based on empirical evidence and are driven by political, social, or financial issues (Rubinstein, Garcia Marti, Souto, Ferrante, & Augustovski, 2009). The

resource allocation decisions should be guided by cost-effectiveness, social acceptance, parity, integration, independence, sustainability, and quality of cardiovascular programs.

Previous studies have found that public health systems, supporting multisector population health activities through network and linkages, may help to minimize the disparities gaps in population health. Evidence driven organizational assessment of a public health agency will help to identify the strengths and areas for improvement at the system level. Such strengths and areas of improvements could then be tailored to cardiovascular conditions and hence be used to inform the quality improvement plans and strategic plans to address cardiovascular needs in the community. Community is an integral partner in any population health activities and informing and educating the community on public health issues will help to promote awareness about the availability of population health services, and health initiatives in the community (Turnock et al., 1994).

Several communities have individually implemented different population health activities to identify and address stroke and cardiovascular health needs in their communities needs assessment (Brigham and Women's Hospital, 2013; BroMenn Medical Center, McLean County Health Department, OSF St. Joseph Medical Center, & United Way of McLean County, 2016; Greenville Health System, 2013; Special Service for Groups, 2013; UPMC Passavant, 2013). The Healthy People 2010 Heart Disease and Stroke Partnership framework involves a cycle of assessment, community-based planning, and widespread and sustained implementation of cardiovascular programs with community participation and evaluation at every step (Veazie et al., 2005). Public health agencies have analyzed the utilization of preventive and screening services such as

regular blood pressure checkups and cholesterol screenings (Pennant et al., 2010). Failure to intensify the utilization of the screening and preventive efforts now will abruptly increase the future burden and cost of cardiovascular disease (Centers for Disease Control and Prevention, 2014). However, at a national level, there is not a single study that looks at the total availability of population health activities recommended by the Institute of Medicine and its effect on mortality from stroke in the community over time. This study attempted to address this gap by examining the longitudinal trends of availability of population health activities and their effect on the mortality rates from stroke in a nationally represented cohort of local health jurisdictions serving at least 100,000 population.

Methods

Study design and sample

We followed a national sample of local public health jurisdictions serving at least 100,000 population over fourteen years using a nationally representative sample of data from the US metropolitan communities selected in 1998 (n=497). These jurisdictions were followed up in 2006, 2012, and 2014. In the national longitudinal survey of local public health systems (NLSPHS), we selected metropolitan communities because they represent approximately 17% of all local health jurisdictions serving about 70% of the US population. For the purpose of this paper we used survey responses for the year 1998, 2006, and 2012 with response rates for each waves ranging from 68% to 78%, with no

indication of systematic differences between responding and nonresponding communities.

Data and Measures

The survey instrument in NLSPHS seeks information from local health directors/administrators about scope, perceived effectiveness, and extent of multi-sectoral contribution to each of twenty different population health activities (Table 1). The scope of population health activities is measured by asking whether each of the 20 population health activities is performed in the jurisdiction. For the purpose of this analysis, we used data from 1998, 2006, and 2012 survey waves and were linked with county-level demographic, health, socioeconomic characteristics obtained from concurrent National Association of City and County Health Officials profile survey data and Health Resources and Services Administration's Area Resource data Files. The final analytical data were obtained by linking the outcome variable, 3-years age adjusted mortality at county-level, from Center for Disease Control and Prevention's Compressed Mortality File.

Dependent variable: We used county-level 3 years age-adjusted mortality rate from stroke per 100,000 population. We also used mortality from Alzheimer's disease as a control condition based on the assumption that this disease would not be influenced by population health activities during the study period. To account for the lag between population health activities and mortality data, we used 3 years age-adjusted mortality after accounting for one year lag between survey measures and mortality rates. Due to

data limitations, we do not address the issue of longer lags in the response of mortality rates and the provision of population health services, though these lags may be important (Farahani, Subramanian, & Canning, 2009). We used ICD-10 codes (Table 2.1) to extract mortality data from Center for Disease Control and Prevention's Compressed Mortality File (Centers for Disease Control and Prevention, National Center for Health Statistics, 2016).

Table 2.1: ICD-10 codes for Stroke and Alzheimer's disease

Chronic condition	**ICD-10 codes (1999-2001; 2007-2009; 2012-2014)**
Stroke	I60-I69 (Cerebrovascular diseases),
Alzheimer's disease (Control Condition)	G30 (Alzheimer's disease)

Independent variables: The 20 population health activities solicited in NLSPHS were originally developed as indicators of Institute of Medicine's (IOM) 3 core functions of population health: assessment, policy development, and assurance. These 20 population health activities serve as an important screening tool to illustrate the scope of population health services within a community. In this study, the main explanatory variable was the composite measure of the scope of all 20 population health activities which was computed as the weighted average of 20 activities performed in the jurisdiction, with activity weights defined such that each of the 3 IOM core functions receives equal weight.

Control variables: To isolate the relationship between the primary variable of interests with the mortality rates, we controlled for an array of other characteristics that are likely to affect community level mortality rates and health outcomes as examined in the prior studies (Mays & Smith, 2011; Mays et al., 2016; Pathman, Fryer, Green, & Phillips, 2005; Ricketts & Holmes, 2007; Rodriguez, Chen, Owusu-Edusei, Suh, & Bekemeier, 2012; Shi, Macinko, Starfield, Politzer, & Xu, 2005; Starfield, Shi, Grover, & Macinko, 2005). We controlled for demographic, socioeconomic factors, and factors related to the health care resources of the community that are likely to reflect underlying health needs and care seeking behavior in the community (Mays & Smith, 2011). The demographic and socioeconomic characteristics used as explanatory variables in this analysis include the community's population size, population density, percent of population non-white, percent of population 65 or older, percent of unemployment, and percent of uninsured in the community. We included population size and population density in the same model. As population size increases, the number of potential agencies contributing to population health activities increases, and as population density increases it increases the linkages, the infrastructure, the demand and the effective market size for population health activities. The measures of medical resources and jurisdictional structures within the community include the number of hospital beds per 100,000 residents, the number of active nonfederal physicians per 100,000 residents, number of federally qualified health centers per 10,000 population below poverty, and jurisdiction type.

Statistical Analysis

A longitudinal research design was used where we examined how changes in the scope of population health activities can influence mortality from stroke over time. Only those observations that responded to all three waves (n=173) were included in the analytical sample. We used random effects regression models with instrumental variables to account for the possibility of endogeneity due to time varying omitted variables - that communities with differing proportion of population health activities may be determined by other, unobserved factors that would influence the community mortality rates from stroke over time (Newhouse & McClellan, 1998). With an assumption that the dependent variable is increasing or decreasing linearly over time, we used time trend (A. D. Smith & Taylor, 2016) as a control variable that allows to control for the exogenous increase in the mortality rates that is not explained by other variables. Use of instrumental variables would allow for a more rigorous assessment of whether the availability of population health activities has causal (rather than spurious) associations with age-adjusted mortality rates from stroke in the community over time. Some examples of unmeasured community characteristics that would influence mortality rates for reasons not related to population health activities are economic distress (Ariizumi & Schirle, 2012), residential migration (Black, Sanders, Taylor, & Taylor, 2015), and capacity of a local health jurisdictions to bring in community grants (Manton, Gu, Lowrimore, Ullian, & Tolley, 2009).

When using instrumental variable models, the selected instruments should be (*i*) external to mortality and population health activities, i.e. they must not be affected by mortality and population health services, and (*ii*) orthogonal to mortality, i.e. they must have an effect on community mortality only through their effect on population health

activities and not have by themselves a direct effect on mortality. Multiple specification tests were conducted to examine the criteria of instruments, relevance and identification of the instruments. In particular, two institutional characteristics were of particular interest when examining the political economy of local public health practice: (i) having local governing board of health with policy and advising authorities, and (ii) the degree to which public health decision making authority is decentralized and delegated from state to the local government level. Theoretically, these political ideologies and cultures within a state or community are likely to shape attitudes about the appropriate role of government in the delivery of population health activities (Mays & Smith, 2009). Previous studies suggest that these instrumental variables were associated with higher spending levels and lower risks of spending reductions that would predict the population health services available in the community (Mays & Smith, 2009; Mays & Smith, 2011) and were not directly related to community mortality rates (Mays et al., 2016). Analysis was conducted using Stata 14. Repeated measures across the survey years were declared using –`xtset`- command with the variable that identifies repeated observations. We used –`xtivreg`- with random effects adjusting for the clustering of the observations in a state. The specification tests were performed using the post-estimation command –`xtoverid`-. Details of the results from two-stage estimation and specification tests were reported in Appendix A2.1.

Results

Sample Characteristics

Of the 497 local health jurisdictions sampled in the initial cohort in 1998, 354 responded in 1998. Those who responded in 1998 were followed up in 2006, and again 2012. The analytical sample of this study included those local health departments that responded in all three waves (n=173). For each wave, we performed t-test for continuous variables and chi-square for categorical variables to compare means of some of the demographic, socioeconomic, health conditions, infrastructure, and healthcare workforce capacity and resources between those responding to all three waves and those responding to only one or two waves of the NLSPHS survey, and found no significant differences (Table 2.2).

Table 2.2: Comparison between local health departments in sample vs not in sample by wave/year

	1998			2006			2012		
Responded to all 3 waves of NLSPHS*	No	Yes	p-value	No	Yes	p-value	No	Yes	p-value
3 years mortality rates per 100,000	62.78	62.91	0.92	45.84	44.32	0.24	39.00	37.52	0.21
% 65 years and above	12.70	12.52	0.68	11.74	12.11	0.53	13.44	13.21	0.67
Hospital beds per 100,000 population	350.00	334.81	0.54	275.73	297.59	0.45	299.57	261.80	0.11
Population size (in '000s)	371.87	427.07	0.48	437.87	487.27	0.72	433.58	484.29	0.66
MDs per 100,000 population	247.10	245.44	0.94	269.37	264.77	0.89	272.18	262.40	0.73
Uninsurance rate	13.72	13.07	0.15	13.55	13.06	0.42	16.35	16.47	0.88
Number of FQHCs	4.30	3.60	0.41	3.81	3.52	0.83	8.04	5.12	0.06
Availability of population health activities	0.62	0.66	0.06	0.70	0.69	0.68	0.62	0.67	0.06
Jurisdiction type									
County/City-county	69.05	78.92		69.23	77.64		79.03	80.63	
City	11.90	6.02	0.08	9.62	5.59	0.42	11.29	6.88	0.50
Others	19.05	15.06		21.15	16.77		9.68	12.50	

*Those responding to all 3 waves of NLSPHS were included in the sample

Implementation of population health activities

Table 2.3 shows the proportion of each of the twenty recommended population health activities implemented in the US metropolitan communities from 1998 to 2012. At least one of the mean proportion of all assessment (p-value=0.001) and policy development activities (p-value=0.018) were significantly different in 1998, 2006, and 2012. However, the mean proportion of assurance and evaluation activities, and overall population health activities were not statistically different across all three survey years. At least one of the means in the survey years for population health activities such as, survey of behavioral risk factors in the community (p-value<0.001), conducting laboratory testing for risk factors (p-value=0.027), providing health information and education to the community (p-value=0.016), developing community wide health improvement plan (p-value=<0.001), and linking people to needed health and social services (p-value=0.002) were significantly different. Using 1998 as the baseline, there is an indication of large improvement in proportion of population health activities such as survey of behavioral risk factors, conducting laboratory testing to identify health hazards and risks, and providing routine health information to the community. However, we observed largest decline from 1998 to 2012 in developing community-wide health improvement planning (16.11 percentage points, p-value<0.001) and in implementation of population health activities that link people to needed health and social services (17.34 percentage points, p-value<0.002).

Table 2.3: Recommended population health activities implemented in US metropolitan communities responding to all 3 waves of the National Longitudinal Survey of Local Public Health Systems, 1998-2012 (n= 173)

	Description of population health activities	1998	2006	2012	p-value*
1	Conduct periodic assessment of community health status and needs	75.14	80.92	76.30	0.276
2	Survey community for behavioral risk factors	49.40	72.83	78.03	<.001
3	Investigate adverse health events, outbreaks and hazards	97.69	98.84	100.00	0.049
4	Conduct laboratory testing to identify health hazards and risks	95.95	96.53	99.42	0.027
5	Analyze data on community health status and health determinants	63.53	74.57	67.05	0.048
6	Analyze data on preventive services use	29.41	26.01	34.10	0.139
	Mean percentage of assessment activities (#1-6)	68.87	74.95	75.82	0.001
7	Routinely provide community health information to elected officials	83.14	91.33	87.86	0.085
8	Routinely provide community health information to the public	75.72	87.28	81.50	0.016
9	Routinely provide community health information to the media	79.77	88.44	87.28	0.049
10	Prioritize community health needs	70.35	72.25	70.52	0.895
11	Engage community stakeholders in health improvement planning	42.69	49.13	52.60	0.145
12	Develop a community-wide health improvement plan	86.05	86.71	69.94	<.001
13	Identify and allocate resources based on community health plan	26.59	36.42	32.37	0.108
14	Develop policies to address priorities in community health plan	52.60	54.34	51.45	0.828
15	Maintain a communication network among health-related organizations	81.50	86.13	88.44	0.208
	Mean percentage of policy and planning activities(#7-15)	66.51	72.45	69.11	0.018
16	Link people to needed health and social services	76.30	68.21	58.96	0.002
17	Implement legally mandated public health activities	92.12	91.33	89.60	0.518
18	Evaluate health programs and services in the community	37.21	36.99	31.21	0.320
19	Evaluate local public health agency capacity and performance	59.54	53.76	58.38	0.469
20	Monitor and improve implementation of health programs and policies	47.06	48.55	45.09	0.812
	Mean percentage of assurance and evaluation activities (#16-20)	62.37	59.77	56.65	0.097
	Overall percentage of all activities implemented	65.92	69.06	67.19	0.120

*p-value<0.05 indicates that at least one of the means for the 3 waves was significantly different at 0.05 level.

Impact on mortality from stroke

Multivariable analysis using instrumental variable approach (Table 2.4) revealed that communities with 1 percentage point increase in total availability of the recommended population health activities, mortality rate from stroke decreases by 0.22 deaths per 100,000 population, i.e. for every additional population health activity, annual deaths from stroke decrease by 1.1 per 100,000 population. A more comprehensive set of additional population health activities will result in greater reduction in the stroke mortality rates. Similarly, as number of Physicians per capita increases by one unit the mortality from stroke decrease by 0.006 per 100,000 population. With a 1% increase in the number of uninsured population, mortality from stroke increase by 0.442 per 100,000 population. As a falsification test, we found that availability of population health activities was not significantly associated (p-value=0.806) with mortality from Alzheimer's disease (Appendix A2.2). Alzheimer's mortality is believed to be unrelated to population health resources and intervention and using it as a dependent variable showed that the availability of population health activities was indeed not related to Alzheimer's mortality rate but the availability was related to stroke mortality. This validates our model of trying to establish a relationship between stroke that is affected by population health resources and intervention.

Specification tests

We tested the validity and relevance of the instruments using a battery of tests (Baum, Schaffer, & Stillman, 2010; Schaffer, 2010) presented under Table 2.4.

Sanderson-Windmeijer (SW) first-stage chi-squared test with 5 degrees of freedom was used as an “under-identification test” to test the null that the instruments are inadequate. Rejection of the null (p-value=0.0004) indicates that the instruments used are not inadequate. Furthermore, the first-stage F statistics and Kleibergen-Paap Wald rk test of weak identification implies absence of “weak instruments” (p-value=0.003) indicating insignificant correlation between the endogenous variables and the instruments. We also tested the orthogonality condition (over-identification) of the instruments using Hansen J’s Statistic. This statistic implied instrumental validity with the failure in rejecting null and that instruments were uncorrelated with errors. Alternatively, we also tested the orthogonality condition by endogeneity test and found that the specified endogenous regressor may not be treated as exogenous (p-value=0.045).

Table 2.4: Estimates for 3 years stroke-mortality rates obtained from the instrumental variable analysis with specification tests of the instruments and the endogenous variable

	Coef.	Robust Std. Err	p-value	[95% CI]
Availability of population health activities	-0.222	0.106	0.036	[-0.429, -0.015]
% non-white	-0.065	0.038	0.086	[-0.139, 0.009]
% population aged 65 years and above	0.116	0.283	0.683	[-0.439, 0.671]
Hospital beds per 100,000 residents	0.004	0.003	0.262	[-0.003, 0.011]
Population size, log	-0.172	1.083	0.874	[-2.294, 1.951]
Population density, log	-0.045	1.279	0.972	[-2.552, 2.462]
Physicians per 100,000 residents	-0.006	0.002	0.002	[-0.009, -0.002]
Unemployment rate	0.197	0.213	0.353	[-0.22, 0.615]
Total Uninsurance rate	0.442	0.118	<0.001	[0.212, 0.672]
FQHCs per 10,000 people in poverty	0.009	0.11	0.934	[-0.206, 0.224]
Jurisdiction				
County/City-County	REF			
City/Township	1.013	1.793	0.572	[-2.5, 4.526]
Other	0.944	1.743	0.588	[-2.472, 4.36]
Survey year	-1.935	0.09	<0.001	[-2.111, -1.759]

Test	Type	Statistics	p-value
Underidentification tests	Sanderson-Windmeijer (SW) first-stage chi-squared (5)	22.9	0.0004
Weak-identification test	First-stage F statistics, F(5, 38)	4.46	0.003
	Kleibergen-Paap Wald rk, F(5,38)	4.46	0.003
	Craig Donald Wald F statistic	341.87*	
Overidentification test of all instruments	Hansen J statistic (overidentification test of all instruments) Chi- squared (4)	3.485	0.4801
Endogeneity test	Endogeneity test of endogenous regressors	4.019	0.045

Note: The instruments used in the analysis were governance structure and jurisdiction with boh with advising authority; *greater than any of the Stock-Yogo weak ID test critical values

Discussion

The availability of population health activities varies considerably across metropolitan communities in the US (Mays, Halverson, Baker, Stevens, & Vann, 2004). Our result suggests that stroke related mortality rate decreases over time in communities with increasing number of recommended population health activities. In 2012, the overall age-adjusted stroke mortality rate was 36.9 per 100,000 population (Murphy SL, Kochanek KD, Xu JQ, Heron M., 2015). For each additional population health activity, the decrease in stroke mortality rates by 1.1 per 100,000 population can be translated to a 3% decrease in overall age-adjusted stroke mortality rates in 2012. Thus, implementation of a comprehensive set of recommended population health activities is expected to increase the magnitude of this decrease that has been demonstrated shown for other diseases (Mays et al., 2016). To our knowledge, using an example of stroke from a nationally representative data, this is the first US study to document improvement in chronic health status by implementing population health activities.

Translating population health activities and clinical care into effective programs for primary, secondary, and tertiary prevention of chronic disease such as stroke, hypertension, and other heart diseases would be an effective strategies to bridge the gaps between public health and clinical care (IOM (Institute of Medicine), 2010). Our study suggests that with the implementation of comprehensive population health activities that ensures assessment, assurance, policy development activities at the community level will significantly contribute in the reduction of mortality from stroke.

Given an intensive knowledge and experience in cardiovascular prevention, existence of national partnerships to support heart disease and stroke prevention (Centers for Disease Control and Prevention, 2014), and evidence of population health activities (Karwalajtys & Kaczorowski, 2010; Pennant et al., 2010) that can contribute effectively in reducing cardiovascular incidence and mortality rates, investing in population health activities (Mays et al., 2016; McCullough & Leider, 2016) clearly helps to achieve the goal of preventing heart disease and stroke.

Improvement in mortality rates (6 per 100,000) for each 1000 increase in number of physicians per 100,000 population suggest that a patient-centered approach in caring patients with chronic illness is valuable and hence physician should include all levels of health promotion and disease prevention activities into their practices (Lawrence, 1990).

This study shows that having more uninsured residents in the community has largest adverse impact on stroke mortality rates. Uninsured adults usually have less access to health care with lower level of preventive care, health care utilization (Kaiser Family Foundation, 2016) that might have led to increase in mortality rates. This study can be used as a baseline to compare the mortality rates after the passage of Affordable Care Act and expansion of Medicare using the 2014 waves of the National Longitudinal Survey of Local Public Health Systems and the contemporaneous mortality data.

When using the findings from this study, several limitations should be considered. Data on population health activities were collected using a self-reported survey administered to local health officials, and therefore may not reflect all relevant activities and contributing organizations in the community. However, information about the supply of population health services as collected from the local public health officials are

reliable and valid (Miller, Moore, Richards, & Monk, 1994; Miller et al., 1995). Moreover, data on concentration, value and quality of the population health delivery services were not collected from the NLSPHS survey. The 20 population health activities assessed in NLSPHS survey may not be a comprehensive list of all population health activities and hence there may be potential of bias due to the effect of unmeasured activities, although we minimized this bias using instrumental variable approach. The one year lag time between population health services and mortality from major heart diseases might be limited and hence might not have reflected long-term effects of the population health activities on mortality rates, especially when compared to using incidence rates. Our findings may not be generalized to rural jurisdictions serving less than 100,000 population. However, the jurisdictions in our study sample represent 70% of the US residents.

From the policy perspective, this study tries to justify the rationale to close the gap between public health and clinical care in reducing mortality from chronic diseases. Previous studies have shown that communities with comprehensive system capital (defined by a composite measure of the availability of population health activities; density of contributing organizations; and centrality of organizations within the delivery system) exhibit reductions in community mortality rates over time (Mays et al., 2016). Our findings also provide an additional incentive to the local health departments creating a comprehensive system capital by implementing comprehensive population health activities to reduce community mortality rates from stroke.

CHAPTER THREE:
RURAL URBAN DIFFERENCES IN RECOMMENDED POPULATION HEALTH ACTIVITIES AND ORGANIZATION OF PUBLIC HEALTH DELIVERY SYSTEM CAPITAL

Background

Residents in rural communities are more likely to experience higher mortality rates and have poorer health status than their urban counterparts and also have a greater percentage of an older population (Eberhardt, Ingram, Makuc, & et al, 2001). Populations with higher poverty rates and lower educational attainment rates are more likely to report unmet health needs, less likely to have insurance coverage, and are less likely to have access to population health services. All of these conditions are more prevalent in rural communities thus magnifying the poor population health status in the rural areas compared to the urban areas (Blumenthal & Kagen, 2002).

Despite the improvement in overall US health status since 2001, the gaps in population health status between rural and urban communities have worsened in 2014. Compared to the urban and sub-urban counterparts, rural communities experience higher incidence of cancer with poor outcomes as well as higher diabetes, injury mortality rates, and suicide rates among those diagnosed with mental disorders (Behringer et al., 2007; Liff, Chow, & Greenberg, 1991; Meit et al., 2014; K. B. Smith, Humphreys, & Wilson, 2008; Weaver, Palmer, Lu, Case, & Geiger, 2013). This difference in health status between the rural and urban communities may not be attributable only to the differences in access to medical care, but also to multiple components such as characteristics of

health delivery systems, characteristics of population at-risk (Aday & Andersen, 1981), and the external environment (Andersen & Davidson, 2001). In addition, there may be rural-urban differences in the availability of "population health activities" that extend beyond medical care and target social, economic, and environmental determinants of health.

Population health has been defined as the health outcomes of a population, including the distribution and patterns of multiple determinants of such outcomes within the population (Kindig & Stoddart, 2003). The determinants of population health include healthcare, public health services, and aspects of the physical or social environments, genetics, and individual behavior. There is a growing body of research that explains the contribution of public health and social services to total population health. In general, public health and social services reflect society's desire and effort, such as vaccinations, motor-vehicle safety, safer workplaces, efforts to prevent and control communicable and non-communicable diseases, and promotion of healthier food and lifestyles (Shi, Tsai, & Kao, 2009).

Despite an improvement in overall life expectancy in the U.S, there is a widening gap in rural-urban differences in life-expectancy over time, with the gap ranging from 0.4 years in 1969-1971 to 2.0 years in 2005-2009. Some of these differences are attributable to inequalities in poverty, educational attainment, spending on public safety, social and welfare services, housing, and unemployment, and healthcare access between rural and urban communities (Singh & Siahpush, 2014). Additionally, some of these differences are due to characteristics of the health care delivery systems that serve rural areas.

About 97% of the total land area in the US is covered by rural communities, where about 19% (60 million) of the total population resides (The Rural Health Information Hub, 2015). Rural populations face unique challenges related to the behavioral, social, economic, and environmental determinants of health which may be best addressed by the comprehensive delivery of population health and social services. Specifically, they face what some refer to as "double disparities": they tend to exhibit risky health behaviors and have access to limited resources; these disparities work in concert to produce poor health outcomes (Harris et al., 2016). Urban health departments operate in communities with a greater resource base that provides flexibility and capacity to adapt service delivery models in a way that might not be possible for rural health departments (N. Hale, 2015). Rural areas also tend to have lower levels of the infrastructure and capacity necessary to compete for private, federal and state grants (Berkowitz, 2004). Residents in rural communities are more likely to report poor health status, less likely to get insured, less likely to have access to preventive care measures (Caldwell, Ford, Wallace, Wang, & Takahashi, 2016), and are more likely to report higher prevalence of chronic diseases, infant and maternal morbidity, mental disorders, and injuries (Larson et al., 2003; National Advisory Committee on Rural Health and Human Services (NACRHHS), 2008; Office of Rural Health Policy, 2005). Rural communities are also consistently more likely to be characterized as health professionals' shortage areas (Committee on The Future of Rural Health Care, Board on Health Care Services, & Institute of Medicine, 2005) with a maldistribution of health care workforce (Burrows, Suh, & Hamann, 2003, Updated 2012). Owing to small population size, loss of even one health care provider will significantly reduce the per-capita health care provider

in rural communities leaving a severe effect on access to care (National Advisory Committee on Rural Health and Human Services (NACRHHS), 2008).

There is evidence of strategies that are linked to improved population health particularly by improving coordination, fragmentation across the medical, public health, and social services sectors (Mays et al., 2016). Traditionally, the rural population health service delivery system emphasized access to care through direct service provision as a fundamental principal of health services delivery (Beatty, Hale, Meit, Masters, & Khoury, 2016) and a primary approach to meeting the population health needs of rural communities. However, given that most healthcare problems reported in rural communities stem from risky health behaviors, a lack of health education, lower utilization of healthcare services, and an increasingly aging population, rural populations may be better served by a public health system that focuses on the delivery of core population health services. Given the resource constraints faced by public health agencies in many rural communities, they may not have the capacity to offer a complete package of preventive services on their own. One strategy to overcome resource limitations is to partner with other public health system partners in the community and to distribute the burden of effort among these partners.

In this paper we identify whether a local health agency is a comprehensive public health system or not. A comprehensive public health system is a composite measure of the strength of the delivery system for population health activities. It is a composite of: (1) availability of population health activities; (2) density of contributing organizations; and (3) centrality of organizations within the delivery system. Specifically, comprehensive public health systems generally perform more than two-thirds of the

population health activities measured by the NLSPHS, through dense networks of contributing organizations and sectors (Mays, Scutchfield, Bhandari, & Smith, 2010). Comprehensive public health systems stand in stark contrast to the other types of public health systems: conventional and limited systems. Conventional public health systems tend to perform a moderate scope of activities with a smaller number of contributing organizations when compared to comprehensive systems. Limited systems tend to perform few activities and involve fewer organizations in those activities when compared to their comprehensive and conventional peers (Mays et al., 2010). However, the rural health disadvantages might be partly due to the gaps in access to population health and social services and from ineffective mechanisms for aligning these services and sectors with medical care. In this paper, we examine following research questions: Are population health and services disproportionately distributed between rural and urban communities? What are the factors that determine the differences in the rural and urban public health systems?

Relatively little is known about how rural and urban communities compare in terms of the quality and quantity of multi-sector relationships supporting population health. Given the shortages of health care services and supplies in rural communities, the mechanisms for cross-sector coordination and alignment may be of particularly importance for rural communities. This paper examines the rural-urban differences in the scope of and multi-sectoral contributions to population health activities.

Conceptual framework

Conceptually, we can model rural urban differences in population health activities using a basic supply and demand framework (Figure 3.1). In this framework, the supply of population health activities in a community would be a function of community capacity and effort to invest in population health activities, and multi-agency relationships between physicians, consumers, and third party payers across the physician services market and health insurance market (Kenkel, 2000). The demand for population health activities for a given community would be related to the socio-economic and health condition of its residents. We can then use this simple supply and demand framework to evaluate how selected supply and demand factors contribute or give rise to differences in population health activities between rural and urban communities. Consider first community capacity to supply population health activities where rural public health systems significantly lag in terms infrastructures and workforce capacity compared to urban public health systems. Compared to their urban counterparts, rural public health systems are characterized by lower funding levels and limited access to grants funding, lack of specialized medical care providers, problems in recruiting and retaining staffs, limited access to transportation, wide geographic coverage area, smaller health centers with limited budgets, and fragmentation among limitedly available resources within rural communities (Berkowitz, 2004). Another factor affecting the disparity in supply of rural versus urban population health activities are the substantial differences in the physician services and health insurance markets in rural and urban health systems (Lillrank, Groop, & Malmstrom, 2010). For example, only 11% of the

physicians practice in rural America, despite the fact that one-fifth of the population lives in this area. More specifically, the clinically active, nonfederal, nonresident national physician/population ratio to 100,000 populations was 191.1 but had a large disproportionate variation between urban (209.6) to rural (52.3) communities (Fordyce, Chen, Doescher, & Hart, 2007).

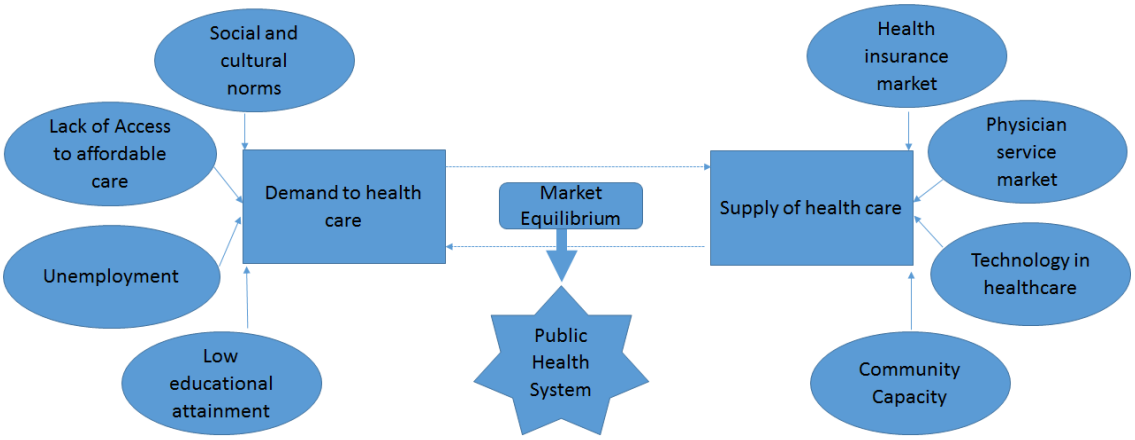

Figure 3.1: Demand-supply framework to health-care, adapted from Alan Maynard and Panos Kanavos (2000), "Health Economics: An Evolving Paradigm", Health Economics 9, 2000, 183-90

Hospitals are an important contributor to the supply of population health activities (Hogg, Mays, and Mamaril 2015). Hospital contributions to population health are even more critical in rural regions where the population is typically older and poorer, more dependent on public insurance programs, and in worse health than urban residents (Arduino, 2015; Kaufman et al., 2016). When differentiating the demand for population health activities between rural and urban communities, one should also consider important social and economic factors. Factors such as the lack of access to affordable

health care, unemployment, poverty, and lower levels of educational attainment are all negatively related to health outcomes, and these factors are common in rural areas than in urban communities (Crosby, Wndel, Vanderpool, & Casey, 2012; N. Hale, 2015). In addition, rural communities spend more on healthcare than the urban communities (Hawk & Consumer Expenditure Program, 2013). Given the differences between rural and urban areas as it relates to the overall supply and demand conditions for population health, we would therefore expect to find differences as well in the availability, scope, and multi-sector contributions in population health activities. To empirically lend evidence to this hypothesis, we present and describe the data and methods used in this study.

Methods

Data

The measures of public health systems composition used in this study were obtained from the National Longitudinal Survey of Public Health Systems (NLSPHS), and were developed in earlier studies of local health performance and reflect cross-cutting strategies based in the disciplines of community psychology, organizational sociology, and urban/rural planning (Mays et al., 2016; Turnock, Handler, & Miller, 1998).

Since 1998, the NLSPHS has followed a nationally representative cohort of U.S public health systems to examine local trends in public health systems composition, and in the delivery of population health services in communities served by these systems. The original cohort of the NLSPHS focused on 100% of the most populous communities – those with 100,000 or more residents - responding to the 1997 National Association of

City and County Health Officials profile survey. The NLSPHS is a unique dataset, as it provides the only longitudinal examination of public health systems composition in the United States (Mays et al., 2004). The NLSPHS provides data on the availability of 20 different population health activities in a community (organized around the three core functions of population health- assessment, assurance and policy development), the percent of effort the local public health agency contributes to these activities, and the range of other organizations that contribute to these activities. The 20 different population health activities were identified using expert panel processes, evidence reviews, case studies, and surveys and were regarded as key services at community level to protecting and promoting communities' population health status (Mays et al., 2010). NLSPHS data also allows the identification of a comprehensive public health systems in communities: comprehensive public health systems generally perform more than two-thirds of the population health activities measured by the NLSPHS, through dense networks of contributing organizations and sectors.

The first three waves of the NLSPHS (1998, 2006, and 2014) focused exclusively on public health systems serving communities with relatively large (at least 100,000 residents) populations spawning a substantial number of reports focused on the infrastructure and performance of public health systems in the nation's most populous communities (Hogg, Mays, & Mamaril, 2015; Ingram, Scutchfield, Mays, & Bhandari, 2012; Mays et al., 2004; Mays et al., 2006; Mays & Hogg, 2015; Rodriguez et al., 2012; Sinclair & Whitford, 2015; S. A. Smith et al., 2015). The cohort of the 2014 wave of the NLSPHS was expanded for the first time to contain a nationally representative sample of

smaller, particularly rural communities allowing us to provide the first ever examination of the differences between public health systems between urban and rural communities.

To expand the cohort in 2014, we used a stratified random sample of public health agencies serving <100,000 population from 2013 National Profile of City and County Health Officials (NACCHO). The sampling strata were based on population categories (<10k, 10k-49k, 50k-99k) and US census regions (northeast, Midwest, south, west) of the communities served by the local health agencies. The 2014 wave of the National Longitudinal Survey of Local Public Health Systems (NLSPHS) was linked with county-level demographic, socio- economic characteristics, and healthcare resources from the U.S. Health Resources and Services Administration's Area Health Resource File and 2013 National Association of City and County Health Officials (NACCHO) Profile Survey.

Measures:

The survey instrument used in the NLSPHS includes questions about scope, perceived effectiveness, and the extent of multi-sectoral contribution to each of twenty different population health activities (Table 3.2). The scope of population health activities is measured by asking local health directors/administrators or public health officials of each local health jurisdiction whether each of the 20 population health activities is performed in their jurisdiction. The survey instrument also asks questions about the range of organizations or sectors involved in each of the population health activities (Mays et al., 2004). Dependent variables included an aggregate measure of the availability of population health services (computed as the average proportion of the activities available

in each community), and the comprehensive structural configuration of each population health delivery system- comprehensive, conventional or limited (Mays et al., 2010). To reiterate, a Comprehensive Public Health System has a broad scope of recommended population health activities (>75%) supported through dense networks of contributing organizations and sectors. A Conventional Public Health System has a moderate scope of recommended population health activities (>50%) implemented through lower-density networks of contributing organizations and sectors. A Limited Public Health System has a narrow scope of recommended population health activities (<50%) implemented through lower-density networks of contributing organizations and sectors.

The main explanatory variable of interest is the rural/urban community indicator variable. In this study, the Rural Urban Continuum Code (Hines, Brown, & Zimmer, 1975) was used to distinguish between urban public health systems (those serving metropolitan communities) and rural systems (those serving non-metropolitan communities). Public health systems serving multi-county jurisdictions were categorized into urban if at least one of the constituent counties was metropolitan. The detail classification of the Rural Urban Continuum Code (RUCC) is provided in Table 3.1.

Table 3.1 Classification of the Rural Urban Continuum Code, 2013 (USDA-ERS, 2016a).

Metropolitan Counties*	
Code	Description
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Nonmetropolitan Counties	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

For the purpose of this paper, as used in the past by Economic Research Service (USDA-ERS, 2016b), we classified non-metropolitan areas (RUCC>3), defined by the Office of Management and Budget (OMB), as rural and all communities with RUCC<=3 as urban. To isolate the relationship between the variable of interest and the dependent variables, an array of other characteristics, that evidence suggests may influence the variables examined (Mays & Smith, 2011; Rodriguez et al., 2012; Ricketts & Holmes, 2007; Starfield et al., 2005; Shi et al., 2005; Pathman et al., 2005; Mays et al., 2016), were controlled (Table 3.4). They include demographic, socioeconomic factors, and factors related to the health care resources of the community that are likely to reflect underlying health needs and care seeking behavior in the community (Mays & Smith, 2011).

Statistical Analysis

We estimated the systematic differences between rural and urban communities for the population average of a composite measure on the availability of population health

activities and structural configuration of the public health system. To do this we used generalized estimating equations (GEE) (Hanley, Negassa, Edwardes, & Forrester, 2003; Zeger & Liang, 1986) that would account for the correlated observations due to clustering. Separate GEE models were specified using linear link function for availability of population health activities and natural log of the odds (logit) link function for comprehensive configuration of the public health system. An unstructured correlation specification (Mays & Hogg, 2015) was used in the GEE models to account for the effect of clustering of the local health jurisdictions in each state. Finally, we report Huber-White Sandwich estimators for robust standard errors.

We assessed multicollinearity between all our control variables and dropped from our model the percent of population with at least 4 years of college education variable as this was highly correlated with personal income per capita. Using Stata package - MFPIgen (Royston & Sauerbrei, 2004), a multinomial fractional polynomial interaction analysis, we found interaction was highly significant between total uninsurance rate and number of federally qualified health centers per 10,000 population below poverty level. In the final GEE model, we used the interaction between total uninsurance rate and number of federally qualified health centers per 10,000 population below poverty level. We also controlled for the interaction between rural/urban settings with the state-local intergovernmental relationship in population health, with centralized states being very different from the non-centralized states (Wholey, Gregg, & Moscovice, 2009). We also controlled for the interaction between income per capita and racial composition of a community, with disproportionate racial composition and household income below

poverty threshold receiving lower support through welfare programs (Probst, Moore, Glover, & Samuels, 2004; McLaughlin & Stokes, 2002; Nord, 1999).

To examine the rural urban differences, we used stratified and pooled analysis for rural and urban settings. This stratification would give us an opportunity to compare estimates across models. Weights were calculated as an inverse of selection probabilities for each jurisdiction. Normalized weights were used in the analyses for rural and pooled models. Stata 14.1 was used for the purpose of all statistical analyses.

Results

Descriptive Statistics

Of the 1,051 local health departments studied in 2014, 36.4% were classified as rural jurisdictions. Oversampling of urban jurisdictions was done to reflect that, while only about 17% of the local health agencies in the U.S. are predominantly located in the urban areas, they serve approximately 80% of the U.S. population. The weighted sample indicate that 48.9% of the jurisdictions are rural and 51.1% are urban.

Public health systems serving urban populations performed 66.4% of the 20 recommended population health activities, while those serving rural communities performed a lower percentage (62.2%) and this difference was significant (p-value=0.04). Systems serving urban communities were significantly more likely to report informing elected officials about population health issues (p-value=0.0007), were more likely to analyze health determinants (p-value=0.0169), to develop a community-wide health improvement plan (p-value=0.0274), and to improve implementation of health programs and policies (p-value=0.0204). When compared to urban communities, public health

systems serving rural communities were more likely to implement mandated population health activities and health initiatives in priority areas (p-value=0.0032). At a more aggregate level, systems serving urban populations had a slightly higher proportion of overall assessment, policy development, and assurance activities (74.0% vs 69.3%, 71.5% vs 66.0% and 53.1% vs 50.8%, respectively) (Table 3.2).

Table 3.3 shows the percent of three different types public health systems (comprehensive, conventional and limited) observed in rural and urban communities. No significant differences were observed in the types of public health systems between rural and urban areas (Table 3.3). Most urban and rural communities were served by conventional public health systems (those that offer a moderate scope of population health activities with fewer contributing organizations and sectors). However, conventional public health systems were more common in rural communities than urban ones. Comprehensive public health systems were observed more frequently in urban than in rural communities.

When compared to rural jurisdictions, the descriptive statistics (Table 3.4) show that urban jurisdictions on average had significantly more health resources such as per capita hospital beds, physicians, and federally qualified health centers. Communities in urban jurisdictions also have a higher proportion of non-white population, higher income per capita, and lower rates of total uninsured when compared to rural jurisdictions. There were also more county/city-county type jurisdictions in rural communities.

Estimates from generalized estimating equations

Stratified and pooled multivariable results for the composite measure of availability of population health activities estimated by our GEE models with linear link function are presented in Table 3.5. Stratified analysis revealed that within rural settings, the proportion of population health activities performed in a centralized local health jurisdiction is .20 percentage points lower than that in a non-centralized jurisdictions (p-value=0.023), after controlling for all other variables. However, this difference was not significant in urban settings. In rural settings, the proportion of population health activities performed in city or township jurisdictions is 0.62 percentage points lower than in county or city-county jurisdictions (p-value<0.001). However, this gap was less for the urban settings, where only 0.10 percentage points lower proportion of population health activities (p-value=0.001) were performed in city or township jurisdiction than county or city-county jurisdictions. In the pooled analysis, the centralized urban (metro) jurisdictions were performing .22 percentage points higher proportion of population health activities than non-centralized rural (non-metro) jurisdictions (p-value=0.03) after controlling for other control variables (Table 4). Depending upon the percentage of uninsured population in a community, there exists different effect of federally qualified health centers per 10,000 population below poverty level on proportion of the available population health activities. More specifically, in communities with 17.6% uninsurance rates – a mean value, one unit increase in FQHC per 10,000 population below poverty level, will increase population health activities by 12.8 percentage points. Similarly, depending upon the percentage of non-white in the community, there exists different

effect of income per capita on proportion of available population health activities. More specifically, in communities with 11.9% of non-white population – a mean value, one unit increase in income per capita, will increase the population health activities by 28.9 percentage points.

We present stratified and pooled multivariable results for the adjusted odds ratio for being in the comprehensive public health system estimated by our GEE models with logit link function in Table 3.6. The stratified analysis revealed that within rural settings, compared to non-centralized jurisdictions, the centralized jurisdictions are less likely to be the comprehensive public health system and the odds ratio decreases by a multiple of (1-0.034) i.e. 0.966 (p-value=0.023), after controlling for all other variables. However, this difference was not significant in urban (metro) settings. In the pooled analysis, the centralized urban jurisdictions were 16 times more likely to be in the comprehensive public health system than the non-centralized rural jurisdictions (p-value=0.031) after controlling for other variables. Public health systems in the city or township jurisdictions were 0.3 times less likely to be comprehensive then those in the county or city-county jurisdictions (p-value=0.026). Depending upon the percentage of uninsured population in a community, there exists different effect of federally qualified health centers per 10,000 population below poverty level on whether a public health systems is comprehensive or not. More specifically, in communities with 17.6% uninsurance rates – a mean value, one unit increase in FQHC per 10,000 population below poverty level, will produce an increase in odds of being in comprehensive public health systems by 18.6 times. Similarly, depending upon the percentage of non-white in the community, there exists different effect of income per capita on odds of being in comprehensive public health

systems. More specifically, in communities with 11.9% of non-white population – a mean value, one unit increase in income per capita, will produce an increase in odds of being in comprehensive public health systems by 12.9 times.

Discussion

These results suggest that urban communities with a centralized jurisdiction enjoy a greater availability of population health activities and a greater likelihood of being in a comprehensive population health system capital than rural non-centralized communities. The stratified analysis showed that the centralized rural communities were performing 0.19 percentage points less population health activities than non-centralized rural communities. For each unit increase in the population density in urban communities, number of population health activities increases by 0.05 percentage points. The interaction effects of total uninsurance rates and number of FQHCs per 10,000 population below poverty level and that of percent of non-white population and income per capita were observed to be significantly more in urban communities than in the rural ones.

This may reflect the limited financial resources available to rural populations, a greater focus of the public health system on clinical services in the presence of fewer medical care providers, or the presence of populations that experience poorer health and greater health disparities (N. L. Hale, Klaiman, Beatty, & Meit, 2016; Berkowitz, Ivory, & Morris, 2002; Berkowitz, 2004). On an average, urban communities performed 7% higher number of population health activities compared to rural ones. In general, of the 20 recommended population health activities, compared to the urban areas the rural areas are less likely to routinely provide community health information to the elected officials,

may lack adequate expertise to analyze data on community health status and determinants, less likely to develop a community-wide health improvement plan and monitor health programs and policies. Informing elected officials with evidence on the community health status of rural communities would help the Senate Rural Health Caucus and House Rural Health Care Coalition to focus attention and act on behalf of rural healthcare concerns in the U.S. Senate and the U.S. House of Representatives (The Rural Health Information Hub, 2014). Consistent with our findings, previous studies have shown that rural communities often have low policy activities (Harris & Mueller, 2013), face barriers in developing standards and collecting consistent, accurate data (National Opinion Research Center (NORC), 2008) thus limiting their capability to analyze the data. However, implementation of the legally mandated population health activities, such as, laboratory, environmental, licensure, and regulatory services, categorical clinical services in WIC, family planning, immunization, disease control, and outbreak investigation, seemed to be most likely to be implemented in rural communities. Given the limitation of population health funding and workforce, particularly in rural communities, the available workforce seem to be more focused on covering only mandated population health activities with limited contribution in building alliance, training, and local strategic planning (Stamatakis, Lewis, Khoong, & Lasee, 2014).

Within a public health system, there exists a flow of information, funding, and policy-making between local, state, and federal health departments. A local health department can only act as an administrative body in its own community and is limited to focus on population health priorities given the economic constraints (Pomeranz, 2011), particularly in rural communities with less federal grants. In addition, with fewer number

of working adults attributed to outmigration and the in-migration of retiring population, the rural communities generate decreasing local tax bases that would reduce the number of population health activities in the community (Eisenhauer & Meit, 2016).

The findings also suggest that the centralized states have fewer number of population health activities and also have weaker population health systems at local levels. Our findings indicate a decentralized government authority may be more informed of and responsive to local community needs. However, in urban areas this relationship was not observed. We found that urban communities with centralized authority were more in favor of greater proportion of population health activities and of comprehensive public health system. This might be due to the fact that the benefits of decentralization could be outweighed by the advantage of the size and economies of scale achievable through centralization (Mays et al., 2009).

In our study, federally qualified health centers (FQHC) per 10,000 population below poverty were associated with non-comprehensive population health system. The main purpose of FQHCs is to provide primary health care services in medically underserved communities. The primary health care services in FQHC programs generally include treatment of acute or chronic medical problems that usually bring a patient to a physician's office (U.S. Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy, 2006) rather than ensuring provision of the population health services in the community. This might be reflected in our findings that the safety net health care is associated with weaker population health systems in the community.

The presence of dense networks of contributing organizations and sectors serving urban populations coupled with a higher resource and income base may facilitate the provision of these recommended health activities. By contrast, rural communities are constrained with limited resources and lower population health system capital, and as a result may have less capacity and flexibility to deliver the recommended population health activities.

To our knowledge, this is the first study to document rural-urban disparities in terms of recommended population health activities and also in terms of multi-sectoral community health planning, implementation, and community coalition using a nationally represented data in the US. This is also the first study to examine the difference in population health system capital between rural and urban geographic regions.

When using the findings from this study, several limitations should be considered. This is a cross-sectional study and thus dos not support causal inference. Data on population health activities were collected using a self-reported survey administered to local health officials, and therefore may not reflect all relevant activities and contributing organizations in the community. However, information about the supply of population health activities as collected from the local public health officials are reliable and valid (Miller et al., 1994; Miller et al., 1995). Moreover, data on concentration, value and quality of the population health delivery services were not collected from the NLSPHS survey. We collected both the exposure and the outcome variables from the same source – NLSPHS. The overall assessment of population health activities and overall effectiveness of population health activities were collected immediately after collecting information of availability, perceived effectiveness, and agencies contributions to the

population health activities in the same survey instrument. This might have influenced there response to the dependent variables causing a possibility of common source bias- a kind of measurement error. To overcome the common source bias, the findings from the subjective ratings of population health status can be compared with the objectively measured population health status to asses if there is any difference in prediction. Similarly to this finding, in a recent study, that used objective measure of community health status, mortality rates, it was found that a comprehensive system capital would predict mortality rates in a community. As a future research direction, we would like to examine the effect of system capital on objectively measured all-cause mortality rates to support my findings from this dissertation. Despite these limitations, our study suggests that there is a disparity between rural and urban communities in terms of scope of population health activities and the range of multi-sectoral collaboration in planning, implementing, and evaluating these activities.

The findings from this study have important policy implications. Evidence suggests that the US communities characterized as transitioning to having comprehensive system capital experience reduced mortality rates (Mays et al., 2016). Therefore, building multi-sectoral system capital across rural communities would help alleviate geographic and socioeconomic disparities in health within the US. Creative solutions exist that may help rural public health systems deliver a more comprehensive set of services in a more effective manner. One potential strategy is sharing services with other agencies across jurisdictions (Pezzino, Libbey, & Nicola, 2014). This allows public health systems to distribute the burden of service delivery among a larger number of partners who would have access to, in aggregate, greater pooled resources. These arrangements can range

from less formal agreements such as memoranda of understanding to more structures options such as regionalizing multiple health departments into a single entity.

Addressing the challenges faced by rural public health systems may demand organized and coordinated approaches to delivering population health services through collaborative networks of public health system members. Creating community coalitions and encouraging broad participation in health planning have been shown to be effective modalities in improving rural population health service delivery (Berkowitz, 2004). Rural public health systems may also benefit from efforts to strengthen their capacity related to resource allocation planning, and resource deployment consistent with the plan. Given the resource limitations faced by rural public health systems, it may take a concerted effort from a wide range of participants to develop the capacity to deliver high quality population health and social services to communities.

Table 3.2: Population health activities in a community by rural and urban settings (2014), N=524

Activities	Rural (n=176)		Urban (n=348)		p-value (Weighted difference)
	Unweighted Mean	Weighted Mean	Unweighted Mean	Weighted Mean	
Conduct periodic assessment of community health status and needs	82.4	82.2	85.0	85.3	0.365
Survey community for behavioral risk factors	57.1	57.0	64.7	60.5	0.4599
Investigate adverse health events, outbreaks and hazards	97.7	96.1	99.7	99.4	0.0774
Conduct laboratory testing to identify health hazards and risks	92.1	90.0	94.5	94.0	0.1333
Analyze data on community health status and health determinants	62.3	59.6	70.0	70.0	0.0169
Analyze data on preventive services use	27.9	30.7	35.7	33.0	0.6068
Routinely provide community health information to elected officials	67.8	64.1	82.7	79.4	0.0007
Routinely provide community health information to the public	75.9	79.8	80.0	79.3	0.8804
Routinely provide community health information to the media	79.9	80.4	83.6	82.6	0.5364
Prioritize community health needs	73.7	75.1	81.3	82.3	0.054
Engage community stakeholders in health improvement planning	59.4	60.1	64.3	63.0	0.5248
Develop a community-wide health improvement plan	70.7	70.7	81.9	79.7	0.0274
Identify and allocate resources based on community health plan	32.8	34.0	41.7	39.1	0.2446
Develop policies to address priorities in community health plan	44.5	48.2	55.8	52.7	0.3328
Maintain a communication network among health-related organizations	79.3	82.1	83.3	82.0	0.9888
Link people to needed health and social services	46.5	45.8	49.4	46.5	0.8824
Implement legally mandated public health activities	93.7	96.4	92.2	93.1	0.0032
Evaluate health programs and services in the community	31.0	33.2	35.6	33.5	0.9504
Evaluate local public health agency capacity and performance	41.6	44.8	50.5	47.9	0.4937
Monitor and improve implementation of health programs and policies	29.5	33.5	46.8	44.3	0.0204
Mean performance of assessment activities (#1-6)	70.0	69.3	75.2	74.0	0.0409
Mean performance of policy and planning activities(#7-15)	64.8	66.0	72.9	71.5	0.0259
Mean performance of implementation and assurance activities (#16-20)	48.4	50.8	54.6	53.1	0.3768
Mean performance of all activities	61.2	62.2	67.8	66.4	0.0434

Table 3.3: Descriptive statistics for the different configurations of public health system, 2014 (N=524)

Population Health System	Rural (n=176)		Urban (n=348)	
	Unweighted Mean	Weighted Mean	Unweighted Mean	Weighted Mean
A. Comprehensive	38.12	29.7	35.1	34.6
1. Centralized	18.48	10.9	15.7	16.4
2. Distributed	10.56	10.9	10.3	10.2
3. Compact	9.09	7.9	9.1	7.9
B. Conventional	45.16	53.3	48.1	48.8
4. Centralized	4.69	2.6	4.1	4.3
5. Distributed	40.47	50.7	44.0	44.5
C. Limited	16.72	17.0	16.9	16.7
6. Centralized	8.21	5.8	8.0	7.2
7. Distributed	8.50	11.2	8.9	9.5
p-value for the Pearson's correlation between metro and 3 categories (A-C) of public health system configurations = 0.5242				
p-value for the Pearson's correlation between metro and 7 categories (1-7) of public health system configurations =0.5263				

Table 3.4: Descriptive statistics for the control variables, 2014

Covariates	Rural (n=176)		Urban (n=348)		p-value
	Unweighted Mean	Weighted Mean	Unweighted Mean	Weighted Mean	(Weighted difference)
% of population unemployed	7.1613	7.2402	7.3069	7.2499	0.9647
Hospital beds per 100,000 residents	0.0035	0.0031	0.0255	0.0336	0.0024
Physicians per 100,000 residents	0.0011	0.001	0.0435	0.0571	0.0001
Total Uninsurance rate	17.568	16.5189	14.8916	14.6539	<0.0001
Number of FQHC per 10,000 population below poverty level	0.0061	0.0056	0.051	0.0474	<0.0001
% of population non-white	11.8638	9.3732	21.9229	20.2437	<0.0001
Income (in dollar) per capita (in 100,000s)	0.3745	0.3713	0.4408	0.4392	<0.0001
Frequency distribution					
Jurisdiction					
County/City-County	81.82	89.30	72.17	69.98	<.0001
City/Township	0.57	0.31	16.23	18.58	
Other	17.61	10.39	11.59	11.44	
Centralization					
Centralized	9.66	7.62	8.02	7.79	0.9462
Non-centralized	90.34	92.38	91.98	92.21	

Table 3.5: Stratified and Pooled coefficient estimates from the multivariable analysis with Composite score for Availability of population health activities

	Rural (n=176)		**Urban** (n=348)		**Pooled** (N=524)	
Characteristics	Est. [95%CI]	p-value	Est. [95%CI]	p-value	Est. [95%CI]	p-value
Rural/Urban Status						
Rural					REF	
Urban					0.055 [0, 0.110]	0.05
Centralization						
Non-centralized	REF				REF	
Centralized	-0.197 [-0.367, -0.027]	0.023	-0.011 [-0.102, 0.079]	0.808	-0.18 [-0.332, -0.029]	0.02
Urban*Centralized					0.217 [0.022, 0.412]	0.03
Adjacent to Urban	0.040 [-0.055, 0.135]	0.411				
Population density	0.005 [-0.035, 0.045]	0.808	0.046 [0.028, 0.063]	<0.001		
Jurisdiction						
County/City-County	REF		REF		REF	
City/Township	-0.615 [-0.942, -0.287]	<0.001	-0.103 [-0.166, -0.040]	0.001	-0.213 [-0.294, -0.133]	<0.001
Other	0.109 [-0.010, 0.228]	0.073	-0.04 [-0.102, 0.021]	0.201	0.001 [-0.053, 0.055]	0.967
% of population unemployed	0.005 [-0.017, 0.026]	0.658	-0.002 [-0.016, 0.012]	0.822	0.003 [-0.011, 0.018]	0.644
Hospital beds per 100,000 residents	-0.657 [-8.318, 7.003]	0.866	0.341 [-0.049, 0.730]	0.086	0.479 [-0.016, 0.974]	0.058
Physicians per capita (in 100,000s)	14.329 [-15.675, 44.333]	0.349	-0.225 [-0.515, 0.066]	0.129	-0.411 [-0.760, -0.061]	0.021
Total Uninsurance rate	-0.024 [-0.038, -0.010]	0.001	-0.003 [-0.008, 0.002]	0.281	-0.012 [-0.018, -0.007]	<0.001
# of FQHC/10,000 population below poverty level	-12.799 [-28.116, 2.518]	0.101	-1.013 [-1.945, -0.081]	0.033	-1.79 [-2.933, -0.647]	0.002
Uninsurance rate*FQHC/10,000 population below poverty	0.709 [-0.415, 1.832]	0.217	0.063 [0.021, 0.105]	0.003	0.109 [0.050, 0.168]	<0.001
% of population non-white	-0.007 [-0.020, 0.007]	0.338	-0.014 [-0.020, -0.009]	<0.001	-0.009 [-0.016, -0.003]	0.004
Income per capita (in 100,000s)	-0.559 [-1.103, -0.016]	0.044	-0.649 [-1.037, -0.261]	0.001	-0.542 [-0.897, -0.188]	0.003
% non-white*Income per capita	0.025 [-0.008, 0.057]	0.133	0.028 [0.016, 0.040]	<0.001	0.025 [0.011, 0.040]	<0.001
Constant	1.144 [0.706, 1.583]	<0.001	0.846 [0.600, 1.092]	<0.001	1.031 [0.812, 1.249]	<0.001

Est. [95%CI]: Coefficient estimates [95% confidence interval for the coefficients]

Table 3.6: Estimates for the Stratified and Pooled Adjusted Odds Ratio from the multivariable analysis with Comprehensive Public Health System

	Rural (n=176)		**Urban** (n=348)		**Pooled** (N=524)	
Characteristics	Est. AOR [95%CI]	p-value	Est. AOR [95%CI]	p-value	Est. AOR [95%CI]	p-value
Rural/Urban Status						
Rural					REF	
Urban					1.225 [0.679, 2.210]	0.501
Centralization						
Non-centralized	REF		REF		REF	
Centralized	0.034 [0.002, 0.622]	0.023	0.736 [0.227, 2.386]	0.609	0.066 [0.008, 0.565]	0.013
Urban*Centralized					16.037 [1.294, 198.681]	0.031
Adjacent to Urban	1.474 [0.510, 4.266]	0.474				
Population density	1.105 [0.682, 1.790]	0.685	1.308 [1.020, 1.677]	0.035		
Jurisdiction						
County/City-County	REF		REF		REF	
City/Township	(only 1 observation)		0.425 [0.149, 1.213]	0.110	0.296 [0.101, 0.867]	0.026
Other	2.231 [0.514, 9.678]	0.284	0.761 [0.321, 1.803]	0.535	1.19 [0.602, 2.353]	0.617
% of population unemployed	1.103 [0.884, 1.377]	0.385	0.929 [0.792, 1.090]	0.368	1.083 [0.939, 1.248]	0.273
Hospital beds per 100,000 residents	0.999 [0.998, 1.001]	0.270	1.001 [1.000, 1.001]	0.009	1.000 [1.000, 1.001]	0.690
Physicians per 100,000 residents	1.002 [0.998, 1.006]	0.413	0.999 [0.999, 1.000]	0.009	1.000 [0.999, 1.000]	0.088
Total Uninsurance rate	0.857 [0.728, 1.009]	0.064	0.979 [0.920, 1.042]	0.501	0.934 [0.877, 0.994]	0.031
# of FQHC per 10,000 population below poverty level (in 1000s)	0.267 [0.041, 1.723]	0.165	0.892 [0.782, 1.018]	0.089	0.838 [0.738, 0.951]	0.006
Uninsurance rate*FQHC/10,000 population below poverty	1.068 [0.946, 1.205]	0.286	1.008 [1.001, 1.014]	0.015	1.011 [1.004, 1.017]	0.001
% of population non-white	0.908 [0.748, 1.102]	0.328	0.913 [0.845, 0.986]	0.021	0.945 [0.880, 1.013]	0.112
Income per capita (in 1000s)	0.968 [0.881, 1.063]	0.494	0.971 [0.922, 1.023]	0.270	0.981 [0.940, 1.024]	0.390
% non-white*Income per capita	1.004 [0.998, 1.011]	0.206	1.002 [1.000, 1.004]	0.053	1.002 [1.000, 1.003]	0.032
Constant	3.493 [0.008, 1591.24]	0.689	1.698 [0.069, 41.691]	0.746	1.47 [0.121, 17.912]	0.763

Est. AOR [95%CI]: Estimated Adjusted Odds Ratio [95% Confidence interval for the odds ratio)

CHAPTER FOUR:
CAN COMPREHENSIVE PUBLIC HEALTH SYSTEMS DETERMINE THE OVERALL PERCEIVED EFFECTIVENESS OF PUBLIC HEALTH ACTIVITIES AND HEALTH STATUS OF A COMMUNITY?

Background:

Recent studies have shown wide variation in several measures of population health. Life expectancy within the US and gaps in the income-related life expectancy have increased over time (Chetty et al., 2016). Morbidity and chronic disability in the US account for approximately 50% of the US health burden which may be an indication of lack of improvements in population health status in the United States (Murray et al., 2013). Though there is an overall decline in the age-standardized death rates for all causes combined, heart disease, cancer, and injuries, the rate of decrease is slower for heart disease, stroke, and diabetes in the US (Ma, Ward, Siegel, & Jemal, 2015) where chronic diseases account for three-quarters of the US health care expenditures (Crook & Peters, 2008).

Healthy People continues to serve as a public health road map by setting health goals while specifying population health and social services to improve longevity and quality of life (Koh, Blakey, & Roper, 2014). The Healthy People 2020 emphasizes the need to consider social determinants of the population health as a multifaceted sector such that the public, policy makers, and the private sector can work together to achieve and sustain health (Koh, Piotrowski, Kumanyika, & Fielding, 2011). Healthy People 2020 also emphasizes the need to have public health infrastructures to effectively provide essential population health services. Turnock B.J referred to the public health

infrastructure as the "nerve center of the public health system" (Turnock, 2001). The current health care system remains too fragmented, too costly, and less accessible (Enthoven, 2009). Having a health metrics such as the percentage of population served by a comprehensive public health system can be used as an indicator to assess the extent of the integration of health systems in the community.

The organizational differences in the delivery of the public health system may determine how a public health systems operate and what the outcome of the systems may be (Mays, Scutchfield, Bhandari, & Smith, 2010). Mays et. al. (Mays et al., 2010) classified public health delivery system capital into seven distinct organizational configurations based on cluster analysis of the system attributes defined by availability of population health activities, density of contributing organizations, and centrality of organizations within the public health delivery system. Three of the seven clusters were further defined as comprehensive systems because they generally performed more than two-thirds of the population health activities measured by the NLSPHS, through dense networks of contributing organizations and sectors.

Policy discussions about improving the fragmented US health care system highlight the need to strengthen the capacities of public health delivery systems. Organizational theory predicts that scope of activities (differentiation), range of organizational contributions (integration), and concentration or distribution of the efforts (centrality) that are driven by the availability of resources, priorities, and incentives tend to improve the community's overall health status.

There is wide use of different measures of health status when assessing quality of care. An accurate assessment of health status measures has been used in the past to track

changes in population health and health service needs (Reeve et al., 2007; Revicki & Regulatory Issues and Patient-Reported Outcomes Task Force for the International Society for Quality of Life Research, 2007; Wilson & Cleary, 1995). Previous studies highlight that the US population health can be improved by enhancing the delivery of population health activities and social services that targets multiple determinants of health and well-being: physical, mental, behavioral, socio-economical and environmental. Despite the knowledge of benefits of public health and social services on population health status, compared to other high-income peer countries, the US is continually lagging behind in the measures of population health status.

There is a paucity of research looking at the associations of the public health systems with an overall perceived health status of the community and an overall rating of the effectiveness of the population health activities. Given the fragmented US health care system, the mechanisms for cross-sector coordination and alignment may be of particularly important in addressing the gaps in the population health status of the communities in the US. This paper examines whether the comprehensive public health system predicts overall ratings of the community health status and effectiveness of population health activities as perceived by the local health directors/administrators. This study will also help us to understand predictors of overall perceived health status of the community and an overall rating of the effectiveness of the population health activities in the community.

Methods

Data

The composite measure of public health system composition and overall population health status in a community used in this study were obtained from the National Longitudinal Survey of Public Health Systems (NLSPHS), and were developed and validated in earlier studies of local health performance (Mays et al., 2016; Turnock et al., 1998).

The NLSPHS is a unique dataset that is the only longitudinal source of information on public health system composition at the national level in the US. Since 1998, the NLSPHS has followed a nationally representative cohort of U.S public health systems to examine local trends in public health system composition, and in the delivery of population health services in communities served by these systems (Mays et al., 2004). The NLSPHS provides data on the availability of 20 different population health activities in a community (organized around the three core functions of public health- assessment, assurance and policy development), the percent of effort the local public health agency contributes to these activities, and range of other organizations that contribute to these activities. NLSPHS data also allows the identification of comprehensive public health systems in communities- a composite measure of the strength of the delivery system for pop health activities. It is a composite of: (1) availability of population health activities; (2) density of contributing organizations; and (3) centrality of organizations within the delivery system. Specifically, comprehensive public health systems generally perform

more than two-thirds of the population health activities measured by the NLSPHS, through dense networks of contributing organizations and sectors.

The first three waves of the NLSPHS (1998, 2006, and 2012) focused exclusively on public health systems serving communities with relatively large (at least 100,000 residents) populations (Mays et al., 2016). Several studies have used these waves of the data to study infrastructure and performance of public health systems in the nation's most populous communities (Hogg et al., 2015; Ingram et al., 2012; Mays et al., 2004; Mays et al., 2006; Mays & Hogg, 2015; Rodriguez et al., 2012; Sinclair & Whitford, 2015; S. A. Smith et al., 2015).

In 2014 wave of the NLSPHS, in addition to the 1998 cohort, we expanded the population to include a nationally representative sample of smaller, particularly rural communities using a stratified random sample of public health agencies serving <100,000 population from 2013 Profile survey of National Association of City and County Health Officials (NACCHO). The sampling strata were based on population category (<10k, 10k-49k, 50k-99k) and US census regions (northeast, Midwest, south, west) of the communities. The 2014 wave of the National Longitudinal Survey of Local Public Health Systems (NLSPHS) was linked with county-level demographic, socio- economic characteristics, and healthcare resources from the U.S. Health Resources and Services Administration's Area Health Resource File and 2013 National Association of City and County Health Officials (NACCHO) Profile Survey. A total of 57% of the local health departments serving at least 100,000 residents (1998 cohort) and 43% of those serving less than 100,000 residents (expanded cohort) responded to the survey in 2014.

Measures

The survey instrument used in the NLSPHS includes questions about the availability, perceived effectiveness, and the extent of multi-sectoral contribution to each of 20 different population health activities (Table 4.1). These 20 different population health activities were identified and validated using expert panel processes, evidence reviews, case studies, and surveys and were regarded as key services at community level to protecting and promoting communities' population health status (Mays et al., 2010). The availability of population health activities is measured by asking the local health directors/administrators whether each of the twenty population health activities is performed in the jurisdiction. The perceived effectiveness of each population health activity is measured using a 5-point Likert scale ranging from "meets no needs" to "fully meets needs". The local health department contribution is also examined as a 5-point Likert scale ranging from "none" to "all" of the level of total community effort contributed by the department. The survey instrument also asks questions about the range of organizations or sectors involved in each of the population health activities, and overall assessment of the population health activities and the overall assessment of the population health status in the community. Specifically, the overall assessment of population health activities was done by asking the local health department's directors/administrators

> "*Public health has been defined by the Institute of Medicine and the World Health Organization as the collection of actions undertaken within society to assure the conditions in which people can be healthy. Thinking about all of the actions*

undertaken within your agency's jurisdiction to promote health, how would you rate the overall effectiveness of these actions in assuring the conditions in which residents of your jurisdiction can be healthy?"

and, the overall assessment of population health status was assessed by asking

"*Thinking about all of the people who reside within your agency's jurisdiction, how would you rate the overall health of this population?*".

The responses to these two assessment questions were collected as a 5-point Likert scale ranging from "Poor" to "Excellent" (Mays et al., 2004). Dependent variables included the above two assessment questions- the response collapsed into 3 categories ("Poor to Fair", "Good", and "Very good to Excellent").

The main explanatory variable of interest is the comprehensive structural configuration of each population health delivery system- comprehensive, conventional or limited (Mays et al., 2010). A comprehensive public health system has a broad scope of recommended population health activities (>75%) supported through dense networks of contributing organizations and sectors. A conventional public health system has a moderate scope of recommended population health activities (>50%) implemented through lower-density networks of contributing organizations and sectors. A limited public health system has a narrow scope of recommended population health activities (<50%) implemented through lower-density networks of contributing organizations and sectors (Mays et al., 2010).

The control variables used in this study include an array of other characteristics, that evidence suggests may influence the relationship between independent and the dependent variables examined (Mays & Smith, 2011; Mays et al., 2016; Pathman et al.,

2005; Ricketts & Holmes, 2007; Rodriguez et al., 2012; Shi et al., 2005; Starfield et al., 2005). Table 4.3 contains a complete list of these variables. They include demographic, and socioeconomic factors, and factors related to the health care resources of the community that are likely to reflect underlying health needs and care seeking behavior in the community (Mays & Smith, 2011). All of these control variables were obtained from the county and jurisdiction level information from U.S. Health Resources and Services Administration's Area Health Resource File and 2013 National Association of City and County Health Officials (NACCHO) Profile Survey.

Conceptual Framework

We can conceptualize this paper by using the culture of health framework. A culture of health is a culture that encourages broad collaborative actions within and across government, private, and voluntary organizations to work towards a shared goal of improving population health, well-being, and equity enabling everyone in our diverse society to lead healthier lives, now and for generations to come. The culture of health action framework includes four interdependent Action Areas: i) Making health a shared value, ii) Fostering cross-sector collaboration, iii) Creating healthier and more equitable communities, and iv) Strengthening integration of health services and systems (Robert Wood Johnson Foundation, 2016).

In this paper we try to look at the association of one of the Action Areas – Strengthening the integrated systems - with the population health status of the community. A public health system can be viewed as a framework with five inter-related components: macro, context, mission, structural capacity, processes, and outcome. The

macro variables that would influence system level usually represent the demographic and economic contexts, socio-cultural values and preferences for population health products, demand, supply and need of population health activities, and public policies. At the system level, we also control for the variation in community level resources such as: number of hospital beds, MDs/Physicians, and federally qualified health centers. The structural attributes of a population health system can be defined in terms of differentiation, integration, and centralization. Highly differentiated systems perform a broad array of population health services in the community and the array of services is determined most likely by the demand- and supply-side factors. The demand-side influence the community's service needs and the supply-side determines the ability and willingness of public health system to provide these services (Dranove & Satterthwaite, 2000; Mays, Halverson, & Kaluzny, 1998; Mays, Halverson, Kaluzny, & Norton, 2000). Similarly, highly integrated systems collaborate with many other organizations to provide these services through sharing of resources and information. Finally, a highly centralized local public health agency carries most of the responsibility and effort to deliver population health services within the system (Mays et al., 2010). Centralization used as a component of system measure should not be confused with one of our control variable: Centralized State, which means that the local health units are led by state health department which primarily retains the decision over the fiscal authority in the local health department (ASTHO, 2014). When a system delivers a broad scope of population health services through dense networks of multi-sector relationships we call such system to be "Comprehensive". Organizational theory predicts that scope of activities (differentiation), range of organizational contributions (integration), and concentration or

distribution of the efforts (centrality) that are driven by the availability of resources, priorities, and incentives are related to the community's overall health status. We use this theoretical foundation to test our hypothesis that a comprehensive public health system structure predicts better health outcome in the community.

Statistical Analysis

Based on the conceptual framework stated above, we estimated the characteristics as well as the distribution of our variables and checked for multicollinearity. To account for the within state variations across multiple jurisdictions responding from a single state, we adjusted for clustering effect within state in statistical analyses. We used separate weighted ordinal logistic regressions to examine association of the public health systems composition with overall assessment of population health status and overall assessment of population health activities in the community after controlling for the effect of the control variables. Proportionality odds assumptions were tested to check for the appropriateness of the models. Weights were calculated as an inverse of selection probabilities for each jurisdiction. Normalized weights were used in the analyses for rural and pooled models. Stata 14.1 was used for the purpose of all statistical analyses.

Results

Of the 524 local health departments that responded to the NLSPHS, 35.1% were classified as those having Comprehensive Public Health Systems typology. However, majority of the local health departments were classified as Conventional Public Health Systems (48.1%). The weighted sample indicates that there are 32.2% of the jurisdictions

to be Comprehensive and 50.9% are Conventional Public Health Systems. Approximately, 24.4% of the local health directors rated the overall population health status of their community to be “Poor to fair” while 47.9% of them rated it to be “Good”. For the overall assessment of the population health activities within their communities, 35.7% of the local health department directors rated them to be “Poor to fair” and 48.0% rated them to be “Good” (Table 4.1). Most of the responding local health departments were county/city-county (75.4%) jurisdictions located mostly in the centralized governance (91.4%). The mean (SE) of each of the continuous control variables is also presented in Table 4.2.

Overall Population Health Status

The bivariate relations between the 3-categories dependent variables (Table 4.3) indicate that the type of public health systems composition was significantly associated with the overall assessment of the population health status. More specifically, compared to Comprehensive Public Health system the odds of having combined “Good” and “Very good to excellent” ratings versus “Poor to fair” ratings of overall population health status for Conventional Public Health systems composition was 0.3 times lower (p-value<0.001), and for Limited Public Health systems composition it was 0.6 times lower (p-value=0.007). This relationship still holds true even after controlling for all other variables in the multivariable model (Table 4.4). Similarly, in the multivariable model we found that after controlling for the effect of other variables, the odds ratio for overall population health status for the *e* fold increase in the number of hospital beds per capita and MDs per capita is respectively 0.91 (p-value=0.036) and 1.14 (p-value<0.001), where

e (=2.7182818) is the base of the natural logarithm used when transforming the predictor. Similarly for each 10% increase in the population above 65 years of age, the odds of having combined "Good" and "Very good to excellent" ratings versus "Poor to fair" ratings of overall population health status increases significantly by $(1.068)^{10}$ i.e. 1.93 times (p-value=0.026) and for each 10% increase in the population with at least college education, the odds of having combined "Good" and "Very good to excellent" ratings versus "Poor to fair" ratings of overall population health status increases significantly by $(1.052)^{10}$ i.e. 1.66 times (p-value=0.026).

Overall Effectiveness of Population health activities

Compared to Comprehensive Public Health system the odds of having combined "Good" and "Very good to excellent" ratings versus "Poor to fair" ratings of overall population health activities for Conventional Public Health systems composition was 0.6 times lower (p-value<0.05) in both the bi-variable (Table 4.3) and multivariable models (Table 4.4). In the multivariable model, for each 100,000s increase in the number of Federally Qualified Health Centers per 10,000 population below poverty, the odds of having combined "Good" and "Very good to excellent" ratings versus "Poor to fair" ratings of overall effectiveness of the population health activities increases significantly by 6.2 times (p-value=0.037). For each 10% increase in the population with at least college education, the odds of having combined "Good" and "Very good to excellent" ratings versus "Poor to fair" ratings of overall effectiveness of population health activities increases significantly by $(1.091)^{10}$ i.e. 2.39 times (p-value<0.001).

Discussion

There appears to be a dose-response relationship between public health system composition and the ratings of perceived overall community health status and perceived effectiveness of the population health activities in communities. The most favorable ratings was observed in communities with comprehensive public health systems than conventional followed by limited public health systems. The Public Health System composition may have also helped the local health department directors to develop subjectively a favorable ratings of their community health status. However, this findings is comparable to the findings from previous study that objectively evaluated the effect of public health system composition on the population health status (Mays et al., 2016). Communities with comprehensive system capital have experienced significantly lower mortality from potentially preventable health conditions compared to those with other type of those system capital (Mays et al., 2016).

This study emphasizes that the LHDs should be encouraged to use resources through multisector partnerships, particularly in communities where support is otherwise limited or unavailable (Winterbauer, Rafferty, Tucker, Jones, & Tucker-McLaughlin, 2016). Results suggests that a community with broad scope of population health activities that are implemented through a dense network of contributing multi-sectoral agencies could help the local health department leaders to develop favorable ratings of their community health status.

To our knowledge, this is the first US study to examine how the perception of local health directors about the community health status is driven by the multisector health planning and implementation activities using a nationally represented data.

However, to interpret the findings from this study, one should consider several limitations. Firstly, this is the cross-sectional study and hence the causal pathway between system composition and perceived population health status and perceived effectiveness of the population health activities cannot be definitively determined. Secondly, the measures of perceived community health status and effectiveness of population health activities were self-reported and hence cannot rule-out the fact that the directors might have subjective influence. However, information about the supply of population health activities as collected from the local public health officials are reliable and valid (Miller et al., 1994; Miller et al., 1995). Thirdly, the intensity, value, and quality of population health activities were not collected from the NLSPHS survey and hence nothing can be inferred about the access and quality of population health services within the community. Despite these limitations, our study suggests that there is an influence of system capital on overall perceived community health status and population health delivery services in a community.

Public health professionals, including local health leaders, are increasingly expected to make policy and programming decisions by engaging in evidence based informed decision making process. This process involves utilization of local health expertise, resources, and knowledge about community health issues, local context, and political climate (National Collaborating Centre for Methods and Tools, 2012). Therefore, from the policy perspective, the perception of local health directors on the overall community health status and the effectiveness of population health services available within their communities is important in influencing how the local health leaders engage themselves in making decisions and priorities (U.S. Centers for Disease

Control and Prevention, 2013) about policy and services within a public health system. This study provides additional information to the policy makers and practitioners to understand how structural differences in the public health systems would influence the overall health status of the community and the effectiveness of the public health activities within their communities. Given the current and potential participants within their communities, the decision makers can make modifications of their system configurations to enhance the overall health status of their communities and the effectiveness of the public health activities delivered within the communities. Our study also affirms the importance of sustainable community-level public health infrastructure to support multi-sector work in population health.

Table 4.1: Distribution of the dependent and independent variables

Variables	N	%-in sample	% weighted
Overall Population health status			
Poor	5	0.98%	0.82%
Fair	120	23.44%	22.82%
Good	245	47.85%	47.27%
Very good	130	25.39%	27.37%
Excellent	12	2.34%	1.72%
Overall Effectiveness of Population health activities			
Poor	24	4.68%	4.82%
Fair	159	30.99%	32.49%
Good	246	47.95%	48.06%
Very good	76	14.81%	13.57%
Excellent	8	1.56%	1.06%
Public Health System			
Comprehensive	181	35.08%	32.23%
Conventional	248	48.06%	50.94%
Limited	87	16.86%	16.84%

Table 4.2: Characteristics of the study sample, 2014

Variables	N	%-in sample	% weighted
Centralized			
non-central	480	91.43%	92.29%
central	45	8.57%	7.71%
Jurisdiction type			
County/City-County	393	75.43%	79.14%
City/Township	57	10.94%	9.91%
Other	71	13.63%	10.94%
	N	**Mean (SE)**	**Mean (SE)**
% nonwhite (log)	524	2.60(0.86)	2.31(0.04)
Hospital beds per capita (log)	524	4.62(4.39)	4.01(0.30)
MD/Physicians per capita (log)	524	5.01(2.76)	4.76(0.12)
FQHC per 10,000 people below poverty (in 100,000s)	524	0.04(0.08)	0.03(0.002)
Unemployment rates	524	7.26(2.12)	7.25(0.10)
Total un-insurance rates	524	15.79(5.51)	15.54(0.13)
% population 65 years and above	524	15.34(4.19)	16.09 (0.12)
% population with at least college education	524	25.77(11.02)	23.09 (0.25)

Table 4.3: Estimates of proportional odds ratio for overall population health status and overall effectiveness of population health activities from bivariate analysis

	Overall Population Health Status		Overall Effectiveness of Population health activities	
	Est. POR*	p-value	Est. POR*	p-value
Public Health System				
Comprehensive	1.00		1.00	
Conventional	0.33[0.22, 0.5]	<0.001	0.62[0.41, 0.95]	0.027
Limited	0.57[0.38, 0.86]	0.007	0.66[0.41, 1.07]	0.091
Centralized				
non-central				
central	0.75[0.34, 1.62]	0.455	0.51[0.23, 1.13]	0.098
Jurisdiction type				
County/City-County	1.00		1.00	
City/Township	0.50[0.32, 0.78]	0.002	1.45[0.94, 2.22]	0.093
Other	0.84[0.58, 1.23]	0.375	1.56[1.09, 2.24]	0.016
% nonwhite (log)	0.89[0.74, 1.08]	0.234	1.13[0.94, 1.37]	0.203
Hospital beds per capita (log)	0.97[0.93, 1.01]	0.186	1.03[0.99, 1.07]	0.144
MD/Physicians per capita (log)	1.026[0.99, 1.07]	0.181	1.16[1.08, 1.25]	<0.001
FQHC per 10,000 people below poverty (in 100,000s)	1.138[0.39, 3.33]	0.813	15.40[2.27, 104.66]	0.005
Total unemployment rates	0.925[0.84, 1.02]	0.113	0.80[0.72, 0.88]	<0.001
Total un-insurance rates	0.975[0.95, 1.00]	0.064	0.90[0.87, 0.93]	<0.001
% population 65 years and above	1.024[0.99, 1.06]	0.199	0.99[0.95, 1.02]	0.401
% population with at least college education	1.023[1.01, 1.04]	0.002	1.09[1.07, 1.11]	<0.001

*Est. POR =Estimated Proportional odds ratio

Table 4.4: Estimates of proportional odds ratio for overall population health status and overall effectiveness of population health activities from multivariable analysis

	Overall Population Health Status		Overall Effectiveness of Population health activities	
	Est. APOR*	p-value	Est. APOR*	p-value
Public Health System				
Comprehensive	1.00		1.00	
Conventional	0.28[0.15, 0.53]	<0.001	0.56[0.32, 0.99]	0.046
Limited	0.55[0.32, 0.95]	0.033	0.71[0.40, 1.25]	0.234
Centralized				
non-central				
central	1.03[0.45, 2.35]	0.947	0.86[0.31, 2.39]	0.779
Jurisdiction type				
County/City-County	1.00		1.00	
City/Township	0.45[0.21, 0.95]	0.037	0.38[0.18, 0.83]	0.015
Other	0.81[0.41, 1.6]	0.538	1.20[0.71, 2.03]	0.501
% nonwhite (log)	0.71[0.44, 1.12]	0.136	1.21[0.71, 2.06]	0.490
Hospital beds per capita (log)	0.91[0.84, 0.99]	0.036	0.95[0.87, 1.04]	0.249
MD/Physicians per capita (log)	1.14[1.06, 1.23]	<0.001	1.07[0.98, 1.17]	0.144
FQHC per 10,000 people below poverty (in 100,000s)	1.35[0.16, 11.63]	0.785	6.20[1.12, 34.33]	0.037
Total unemployment rates	0.92[0.78, 1.09]	0.322	0.91[0.80, 1.04]	0.161
Total un-insurance rates	1.02[0.97, 1.07]	0.507	0.98[0.92, 1.03]	0.400
% population 65 years and above	1.07[1.01, 1.13]	0.026	1.06[0.99, 1.13]	0.094
% population with at least college education	1.05[1.02, 1.09]	0.005	1.09[1.06, 1.13]	<0.001

*Est. APOR = Estimated adjusted proportional odds ratio.

Note: Each model is adjusted for the peer effect.

CHAPTER FIVE:
CONCLUSIONS

Summary

Population health services in the United States is delivered through the collective actions of multiple government, private, and voluntary organizations that differ broadly in terms of their missions and purposes, capacity, and processes. In 2010, President Obama signed the Patient Protection and Affordable Care Act, commonly known as ACA. The provisions of ACA is intended to increase access to insurance coverage, control costs, and target prevention and improvement of health outcomes at population level. In addition, ACA also encourages quality improvement, prevention, and public health initiatives making the governments responsible to uphold good quality in health-related goods and services under the rights to health by supporting broader availability and accessibility to health commodities, particularly in the form of greater public health infrastructure and more affordable services (Gable, 2011).

New and resurging diseases, leadership deficit, and a persistent indigent care burden has put the nation's population health status in dismay (Institute of Medicine, 1988). Owing to these emerging health threats, and the trends in health care policy and health care market, there has been considerable focus on the performance of the nation's public health systems. New evidence is required to align the delivery of population health practices, and to access its effectiveness to promote community well-being and resiliency, realize efficiencies in resource utilizations and reduce disparities in population health (Systems for Action National Program Office, 2015). Without effective

coordination and collaborations between the multitudes of entities constituting the public health system, the delivery of population health activities might not be effective and the mission of reducing disparities, inequities, and inefficiencies in population health activities might be unattainable. The purpose of this dissertation was to examine local trends and disparities in public health systems compositions, and in the delivery of twenty population health services recommended by national and federal guidelines and panel of expert's opinions in communities served by these systems. These twenty population health activities include assessing, investigating, and analyzing community health needs, hazards and risks, setting priorities and planning of population health needs, engaging multi-sector communities in health improvement planning, allocating and deploying resources based on community health planning and prioritization, monitoring and evaluating health programs, policies, and resources in the community, providing health information to the stakeholders, and maintaining communication network among multi-sector organizations to contribute in the total population health (Mays, Halverson, Baker, Stevens, & Vann, 2004).

Data from a nationally represented sample of local health departments responding to the National Longitudinal Survey of Local Public Health Systems in 1998, 2006, 2012, and 2014 was used to conduct three studies:

1. Local Public Health Systems and the burden of major heart diseases: A longitudinal analysis using National Longitudinal Survey of Local Public Health System
2. Rural Urban Differences in Recommended Population Health Activities and Organization of Public Health Delivery System Capital

3. Can comprehensive public health system determine the overall perceived effectiveness of public health activities and health status of a community?

Chapter Two examined the total availability of the recommended set of population health activities and their influence on the trends in the mortality rates from stroke in a nationally represented cohort of local health jurisdictions serving at least 100,000 population. This chapter uses instrumental variable approach after controlling for a set of control variables that influence community health status to determine changes in the mortality rates from stroke. We found that for every additional population health activity, annual deaths from stroke decrease by 1.1 per 100,000 population (p-value=0.036). From the national data, the 3 years stroke mortality rate from 2010 to 2014 decreased by 1.5 per 100,000 (Centers for Disease Control and Prevention (CDC), 2015). This decrement might be improved by implementing comprehensive set of the recommended population health activities in the community. From the policy perspective, this study highlights the importance of closing the gap between public health and clinical care in reducing mortality from stroke thus contributing in reducing burden of chronic diseases. This study also provides an additional incentive to the local health departments creating a comprehensive system capital by implementing comprehensive population health activities to reduce community mortality rates.

Chapter Three examines the rural-urban differences in the scope of and multi-sectoral contributions to population health activities using generalized estimating equations (GEE) that accounts for correlation due to clustering within each state. This is the first study to compare rural and urban communities in terms of the quality and quantity of

multi-sector relationships supporting population health. These results suggest that urban communities with a centralized jurisdiction enjoy a greater availability of population health activities and a greater likelihood of being in a comprehensive population health system capital than rural non-centralized communities. The stratified analysis showed that the centralized rural communities were performing 0.19 percentage points less population health activities than non-centralized rural communities (p-value=0.023). Given the shortages of health care services and supplies in rural communities, the mechanisms for cross-sector coordination and alignment may be of particularly importance for rural communities. The findings emphasizes in building multi-sectoral system capital across rural communities to help alleviate geographic and socioeconomic disparities in health within the US which, in rural communities with resource limitation, can be achieved by sharing resources and services with other agencies across jurisdictions, creating community coalitions and encouraging broad stakeholders participation in health planning and implementation.

Compared to its peer countries in Organization for Economic Co-operation and Development (OECD), there is no doubt that the US health care system is costly and fragmented (OECD, 2014). Chapter Four provides us an empirical evidence to study the mechanisms for cross-sector coordination and alignment that may be of particularly important in addressing the gaps in the population health status of the communities in the US. The primary objective of this chapter was to examine whether the comprehensive public health system predicts overall ratings of the community health status and effectiveness of population health activities as perceived by the local health directors/ administrators and help us understand the predictors of overall perceived health status of

the community and an overall rating of the effectiveness of the population health activities in the community. Considering Comprehensive Population health Systems to be superior in terms of scope of population health activities and degree of multi-sector contributions to Conventional and Conventional to Limited Public Health Systems (Mays, Scutchfield, Bhandari, & Smith, 2010), findings from the ordinal logistic regression showed that there was a gradient of dose-response relation with the ratings for the community health status such that the odds of community health status for the comprehensive public health systems was more favorable than other public health systems configurations. This chapter provides information to the policy makers and practitioners to understand how structural differences in the public health systems would influence the overall health status of the community and the effectiveness of the population health activities within their communities.

Strengths and Limitations

This dissertation uses a unique dataset from the National Longitudinal Survey of Local Public Health Systems (NLSPHS) which is the only national, longitudinal source of information about local public health systems and how they evolve and change over time. It provides an opportunity to examine the organization, financing, and delivery of public health services. In particular, we can compare how local public health systems are responding to the economic downturn and to the implementation of health systems reform under the Affordable Care Act (ACA).

The methods used in this dissertation, have some distinct advantages. For example, the instrumental variable method used in Chapter Two controls for the

unmeasured characteristics of the communities with different numbers of the available population health activities that would explain their differential mortality rates allowing for a true (rather than spurious) relationship of scope of population health activities with stroke mortality rates. Similarly, Chapter Four also uses generalized estimating equations method that would allow for the adjustment of the autocorrelation between local health departments within the same state. This dissertation also provides empirical evidence to inform the policy makers in emphasizing the importance of building strong incentives and infrastructure to promote population health and welfares.

However, the findings from this dissertation need to be used considering the limitations. Data on population health activities were collected using a self-reported survey administered to local health officials, and therefore may not reflect all relevant activities and contributing organizations in the community. Moreover, data on concentration, value and quality of the population health delivery services were not collected from the NLSPHS survey. The 20 population health activities assessed in NLSPHS survey may not be a comprehensive list of all population health activities in a community. In Chapter Two, due to data limitations, we did not address the issue of longer lags in the response of stroke mortality rates and the provision of population health services, though these lags may be important. In Chapter Three and Four, we used a cross-sectional study design and thus the findings in these chapters do not support causal inference. In Chapter Four, the measures of perceived community health status and effectiveness of population health activities were self-reported and hence cannot rule-out the fact that the responding directors might have subjective influence.

Future Research

The delivery, financing, and organization systems for public health prevention, medical care, and social and community services catalyze a range of factors that define population health and well-being. However, these systems interact in a complex and often poorly understood mechanisms through fragmented mechanisms of funding strategies, communication and information network, governance and decision making structures (Systems for Action National Program Office, 2015). More evidence is needed to underscore the importance of building system capital in closing the geographic and socioeconomic disparities in population health.

The onset of Affordable Care Act took place in 2010. In addition to the use of mortality data, we can compare the community health status pre- and post- ACA by using incidence data of some measure health conditions in the community. This would give an empirical evidence to the policy makers, especially in the changed political environment, to advocate for the Affordable Care Act in the changed political environments.

The NLSPHS data is a unique data involving information about population health activities. This data can be linked in future with patient or population-level information at counties to conduct a multilevel analysis that would not only account for the social or aggregate level contexts but also for the individual level characteristics. Inferences can be made at individual level using such hierarchical models.

The data from NLSPHS can also be used to analyze the availability of population health services and system configurations and their effect on the health care utilization and costs. This type of analysis would help to provide evidence of offsetting medical care

costs owing to population health interventions in the community. For example, such type of analysis would provide an evidence to support the statement that “75% of the health care cost that is accounted for preventable chronic conditions would have been minimized by using population health interventions” (Institute of Medicine, 2012).

APPENDICES

A2.1 Detail tables including first-stage results from the instrumental variable approach in Stata

```
. xi: xtivreg avgmort3 pctnonwh pct65 bedcap lnpop lnpopdens mdpcap unemprate
uninstot /*povpct*/ /*fqhcany*/ fqhcppov /*povpct*/ /*jurcounty*/ i.juris_rec
yearsurvey (avtot_gpm1pct = i.governance i.governanc

> e_advice /*i.governance_policy*/), re vce(cluster state)

i.juris_rec       _Ijuris_rec_1-3     (naturally coded; _Ijuris_rec_1 omitted)

i.governance      _Igovernanc_1-4     (naturally coded; _Igovernanc_1 omitted)

i.governance_~e   _Igovernanca0-2     (naturally coded; _Igovernanca0 omitted)


G2SLS random-effects IV regression              Number of obs     =    104,276

Group variable: nacidnum                        Number of groups  =        173


R-sq:                                           Obs per group:

     within  = 0.7793                                         min =        600

     between = 0.0717                                         avg =      602.8

     overall = 0.5309                                         max =        603

                                                Wald chi2(13)     =    1680.99

corr(u_i, X)       = 0 (assumed)                Prob > chi2       =     0.0000


                                (Std. Err. adjusted for 39 clusters in state)
------------------------------------------------------------------------------
             |               Robust
     avgmort3 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
avtot_gpm1pct |  -.2217621    .105674    -2.10   0.036    -.4288794   -.0146449
     pctnonwh |  -.0647152   .0377027    -1.72   0.086    -.1386111    .0091806
        pct65 |    .115526   .2831656     0.41   0.683    -.4394684    .6705203
       bedcap |   .0038689    .003449     1.12   0.262    -.0028911    .0106289
        lnpop |  -.1716052   1.082828    -0.16   0.874    -2.293909    1.950698
    lnpopdens |  -.0450601   1.278996    -0.04   0.972    -2.551846    2.461725
```

```
       mdpcap |  -.0057927   .0018333    -3.16   0.002    -.0093859   -.0021994
    unemprate |   .1974679   .2127808     0.93   0.353    -.2195747    .6145105
     uninstot |   .4419486    .117545     3.76   0.000     .2115646    .6723326
     fqhcppov |   .0090366   .1095724     0.08   0.934    -.2057213    .2237945
_Ijuris_rec_2 |   1.013243   1.792501     0.57   0.572    -2.499994     4.52648
_Ijuris_rec_3 |   .9440831   1.742791     0.54   0.588    -2.471724     4.35989
   yearsurvey |  -1.935103   .0896671   -21.58   0.000    -2.110847   -1.759359
        _cons |   3938.871   174.2628    22.60   0.000     3597.322     4280.42
--------------+----------------------------------------------------------------
      sigma_u |  7.6941665
      sigma_e |  5.5920172
          rho |  .65435657   (fraction of variance due to u_i)
------------------------------------------------------------------------------
Instrumented:   avtot_gpm1pct
Instruments:    pctnonwh pct65 bedcap lnpop lnpopdens mdpcap unemprate uninstot
                fqhcppov _Ijuris_rec_2 _Ijuris_rec_3 yearsurvey _Igovernanc_2
                _Igovernanc_3 _Igovernanc_4 _Igovernanca1 _Igovernanca2
------------------------------------------------------------------------------
```

```
. xtoverid, robust cluster(state) noisily

First-stage regressions
----------------------
First-stage regression of __00000H:

Statistics robust to heteroskedasticity and clustering on state
Number of obs =                 104276
Number of clusters (state) =        39
------------------------------------------------------------------------------
             |               Robust
    __00000H |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    __00000K |  -11.78842   3.938468    -2.99   0.003    -19.50777   -4.069075
    __00000N |  -5.853875   3.703435    -1.58   0.114    -13.11256    1.404808
    __00000Q |   1.960656    2.44645     0.80   0.423    -2.834353    6.755666
    __00000T |   2.572203   2.391623     1.08   0.282    -2.115347    7.259753
    __00000W |   .9129432    2.96373     0.31   0.758    -4.895928    6.721815
    __00000Z |   .2102114   .1179576     1.78   0.075    -.0209838    .4414066
    __000012 |   .5804793   .3518219     1.65   0.099    -.1090869    1.270046
    __000015 |  -.0016915   .0084892    -0.20   0.842    -.0183302    .0149472
    __000018 |   1.377986   1.899471     0.73   0.468    -2.344951    5.100924
    __00001B |  -1.583006    1.27972    -1.24   0.216     -4.09124    .9252276
    __00001E |  -.0044643   .0045486    -0.98   0.326    -.0133796    .0044509
    __00001H |  -.3834366   .5593153    -0.69   0.493    -1.479687     .712814
    __00001K |   -.336427   .3209003    -1.05   0.294    -.9653873    .2925333
    __00001N |  -.0192354   .1602708    -0.12   0.904     -.333364    .2948932
    __00001Q |    1.23669   2.718597     0.45   0.649    -4.091725    6.565104
    __00001T |  -2.183633   2.673846    -0.82   0.414    -7.424336     3.05707
    __00001W |   .1136867   .1601957     0.71   0.478    -.2002947     .427668
    __00000D |  -172.5949   317.8235    -0.54   0.587    -795.5248     450.335
------------------------------------------------------------------------------
F test of excluded instruments:
  F(  5,    38) =     4.46
```

```
  Prob > F      =   0.0027
Sanderson-Windmeijer multivariate F test of excluded instruments:
  F(  5,    38) =     4.46
  Prob > F      =   0.0027


Summary results for first-stage regressions
-------------------------------------------

                                          (Underid)           (Weak id)
Variable     | F(  5,    38)  P-val | SW Chi-sq(  5) P-val | SW F(  5,    38)
__00000H     |       4.46    0.0027 |       22.90   0.0004 |        4.46

NB: first-stage test statistics cluster-robust

Stock-Yogo weak ID F test critical values for single endogenous regressor:
                                 5% maximal IV relative bias    18.37
                                10% maximal IV relative bias    10.83
                                20% maximal IV relative bias     6.77
                                30% maximal IV relative bias     5.25
                                10% maximal IV size             26.87
                                15% maximal IV size             15.09
                                20% maximal IV size             10.98
                                25% maximal IV size              8.84
Source: Stock-Yogo (2005).  Reproduced by permission.
NB: Critical values are for i.i.d. errors only.

Underidentification test
Ho: matrix of reduced form coefficients has rank=K1-1 (underidentified)
Ha: matrix has rank=K1 (identified)
Kleibergen-Paap rk LM statistic          Chi-sq(5)=6.82     P-val=0.2343

Weak identification test
Ho: equation is weakly identified
```

```
Cragg-Donald Wald F statistic                                    341.87
Kleibergen-Paap Wald rk F statistic                               4.46

Stock-Yogo weak ID test critical values for K1=1 and L1=5:
                                     5% maximal IV relative bias    18.37
                                    10% maximal IV relative bias    10.83
                                    20% maximal IV relative bias     6.77
                                    30% maximal IV relative bias     5.25
                                    10% maximal IV size             26.87
                                    15% maximal IV size             15.09
                                    20% maximal IV size             10.98
                                    25% maximal IV size              8.84
Source: Stock-Yogo (2005).  Reproduced by permission.
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.

Weak-instrument-robust inference
Tests of joint significance of endogenous regressors B1 in main equation
Ho: B1=0 and orthogonality conditions are valid
Anderson-Rubin Wald test           F(5,38)=        2.28     P-val=0.0655
Anderson-Rubin Wald test           Chi-sq(5)=     11.72     P-val=0.0388
Stock-Wright LM S statistic        Chi-sq(5)=     15.68     P-val=0.0078

NB: Underidentification, weak identification and weak-identification-robust
    test statistics cluster-robust

Number of clusters             N_clust  =         39
Number of observations               N  =     104276
Number of regressors                 K  =         14
Number of endogenous regressors      K1 =          1
Number of instruments                L  =         18
Number of excluded instruments       L1 =          5

IV (2SLS) estimation
--------------------
```

Estimates efficient for homoskedasticity only

Statistics robust to heteroskedasticity and clustering on state

Number of clusters (state) =	39	Number of obs =	104276
		F(14, 38) =	505.38
		Prob > F =	0.0000
Total (centered) SS =	14539368.15	Centered R2 =	0.7760
Total (uncentered) SS =	14752754.91	Uncentered R2 =	0.7792
Residual SS =	3256899.184	Root MSE =	5.589

	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
__00000H	-.2217621	.1043039	-2.13	0.033	-.4261941	-.0173302
__00000Z	-.0647152	.0372138	-1.74	0.082	-.137653	.0082226
__000012	.115526	.2794942	0.41	0.679	-.4322727	.6633246
__000015	.0038689	.0034043	1.14	0.256	-.0028035	.0105412
__000018	-.1716052	1.068789	-0.16	0.872	-2.266392	1.923182
__00001B	-.0450601	1.262413	-0.04	0.972	-2.519344	2.429224
__00001E	-.0057927	.0018096	-3.20	0.001	-.0093394	-.002246
__00001H	.1974679	.210022	0.94	0.347	-.2141677	.6091034
__00001K	.4419486	.116021	3.81	0.000	.2145516	.6693456
__00001N	.0090366	.1081517	0.08	0.933	-.2029369	.2210101
__00001Q	1.013243	1.769261	0.57	0.567	-2.454444	4.48093
__00001T	.9440831	1.720195	0.55	0.583	-2.427437	4.315603
__00001W	-1.935103	.0885045	-21.86	0.000	-2.108569	-1.761637
__00000D	3938.871	172.0034	22.90	0.000	3601.751	4275.992

Underidentification test (Kleibergen-Paap rk LM statistic): 6.820

Chi-sq(5) P-val = 0.2343

Weak identification test (Cragg-Donald Wald F statistic): 341.870

```
                        (Kleibergen-Paap rk Wald F statistic):          4.462
Stock-Yogo weak ID test critical values:  5% maximal IV relative bias    18.37
                                         10% maximal IV relative bias    10.83
                                         20% maximal IV relative bias     6.77
                                         30% maximal IV relative bias     5.25
                                         10% maximal IV size             26.87
                                         15% maximal IV size             15.09
                                         20% maximal IV size             10.98
                                         25% maximal IV size              8.84
Source: Stock-Yogo (2005).  Reproduced by permission.
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.
------------------------------------------------------------------------------
Hansen J statistic (overidentification test of all instruments):         3.485
                                                      Chi-sq(4) P-val =    0.4801
------------------------------------------------------------------------------
Instrumented:         __00000H
Included instruments: __00000Z __000012 __000015 __000018 __00001B __00001E
                      __00001H __00001K __00001N __00001Q __00001T __00001W
                      __00000D
Excluded instruments: __00000K __00000N __00000Q __00000T __00000W
------------------------------------------------------------------------------

Test of overidentifying restrictions:
Cross-section time-series model: xtivreg g2sls  robust cluster(state)
Sargan-Hansen statistic   3.485  Chi-sq(4)    P-value = 0.4801

.
end of do-file
```

Appendix A2.2

```
. xi: xtivreg avgmortalz3 pctnonwh pct65 bedcap lnpop lnpopdens mdpcap
unemprate uninstot /*povpct*/ /*fqhcany*/ fqhcppov /*povpct*/ /*jurcounty*/
i.juris_rec yearsurvey (avtot_gpm1

> pct = i.governance i.governance_advice /*i.governance_policy*/), re
vce(cluster state)

i.juris_rec       _Ijuris_rec_1-3     (naturally coded; _Ijuris_rec_1 omitted)

i.governance      _Igovernanc_1-4     (naturally coded; _Igovernanc_1 omitted)

i.governance_~e   _Igovernanca0-2     (naturally coded; _Igovernanca0 omitted)


G2SLS random-effects IV regression              Number of obs     =    100,469

Group variable: nacidnum                        Number of groups  =        168


R-sq:                                           Obs per group:

     within  = 0.2284                                         min =        201

     between = 0.0142                                         avg =      598.0

     overall = 0.0729                                         max =        603



                                                Wald chi2(13)     =      56.92

corr(u_i, X)       = 0 (assumed)                Prob > chi2       =     0.0000

                                  (Std. Err. adjusted for 39 clusters in state)
------------------------------------------------------------------------------
             |               Robust
  avgmortalz3 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+---------------------------------------------------------------
avtot_gpm1pct |   .0414036   .1686277     0.25   0.806    -.2891006    .3719077
     pctnonwh |   .0417478   .0513185     0.81   0.416    -.0588347    .1423302
        pct65 |  -.2634285   .2441877    -1.08   0.281    -.7420276    .2151706
       bedcap |   .0059848    .002898     2.07   0.039     .0003048    .0116647
        lnpop |  -.2058932   .7274529    -0.28   0.777    -1.631675    1.219888
    lnpopdens |  -.2749238   .4974525    -0.55   0.580    -1.249913    .7000651
       mdpcap |  -.0024214   .0021163    -1.14   0.253    -.0065692    .0017264
    unemprate |  -.1279325   .2179671    -0.59   0.557    -.5551402    .2992751
```

```
     uninstot |   -.158889   .1360518    -1.17   0.243    -.4255456    .1077676
     fqhcppov |  -.0030251   .0659428    -0.05   0.963    -.1322705    .1262203
_Ijuris_rec_2 |  -.5554988   .6380356    -0.87   0.384    -1.806026    .6950279
_Ijuris_rec_3 |   .5826132   1.489019     0.39   0.696    -2.335809    3.501036
   yearsurvey |   .4989727   .0886686     5.63   0.000     .3251854    .6727601
        _cons |  -970.7945   176.1372    -5.51   0.000    -1316.017   -625.5719
--------------+------------------------------------------------------------------
      sigma_u |  7.3235534
      sigma_e |  4.3657856
          rho |  .73780576   (fraction of variance due to u_i)
------------------------------------------------------------------------------
Instrumented:   avtot_gpm1pct
Instruments:    pctnonwh pct65 bedcap lnpop lnpopdens mdpcap unemprate uninstot
                fqhcppov _Ijuris_rec_2 _Ijuris_rec_3 yearsurvey _Igovernanc_2
                _Igovernanc_3 _Igovernanc_4 _Igovernanca1 _Igovernanca2
------------------------------------------------------------------------------

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Table A3.1: Bivariate analysis of Availability of Population health activities

	Rural (n=176)		**Urban** (n=348)		**Pooled** (N=524)	
	Est. [95%CI]	p-value	Est. [95%CI]	p-value	Est. [95%CI]	p-value
Metropolitan Status						
Nonmetro					REF	
Metro					0.044 [-0.008, 0.097]	0.098
Centralization						
Non-centralized	REF		REF		REF	
Centralized	-0.199 [-0.346, -0.053]	0.007	-0.046 [-0.126, 0.034]	0.260	-0.089 [-0.208, 0.031]	0.147
Total Uninsurance rate	-0.018 [-0.027, -0.009]	<0.001	0.003 [-0.001, 0.008]	0.151	-0.003 [-0.008, 0.002]	0.247
Number of FQHC per 10,000 population below poverty level	-1.062 [-3.773, 1.649]	0.443	-0.061 [-0.281, 0.160]	0.590	-0.041 [-0.261, 0.178]	0.712
% of population non-white	-0.003 [-0.007, 0.002]	0.254	-0.001 [-0.003, 0.000]	0.112	-0.001 [-0.002, 0.001]	0.318
Income per capita (in 100,000s)	-0.124 [-0.544, 0.295]	0.561	-0.107 [-0.325, 0.111]	0.335	-0.111 [-0.326, 0.103]	0.309
Jurisdiction						
County/City-County	REF		REF		REF	
City/Township	-0.283 [-0.333, -0.232]	<0.001	-0.172 [-0.237, -0.108]	<0.001	-0.164 [-0.232, -0.095]	<0.001
Other	0.036 [-0.049, 0.121]	0.411	-0.059 [-0.119, 0.001]	0.054	-0.011 [-0.063, 0.042]	0.691
% of population unemployed	0.007 [-0.009, 0.024]	0.395	-0.010 [-0.022, 0.003]	0.139	0.003 [-0.009, 0.015]	0.577
Hospital beds per 100,000 residents	-9.390 [-17.038, -1.743]	0.016	-0.228 [-0.498, 0.042]	0.098	-0.161 [-0.381, 0.060]	0.153
Physicians per capita (in 100,000s)	-1.772 [-23.532, 19.989]	0.873	-0.186 [-0.357, -0.015]	0.033	-0.140 [-0.300, 0.021]	0.087

Table A3.2: Bivariate analysis of Comprehensive Public Health System

	Rural (n=176)		**Urban** (n=348)		**Pooled** (N=524)	
	OR [95%CI]	p-value	OR [95%CI]	p-value	OR [95%CI]	p-value
Metropolitan Status						
Nonmetro					REF	
Metro					1.252 [0.774, 2.025]	0.359
Centralization						
Non-centralized	REF		REF		REF	
Centralized	0.067 [0.008, 0.556]	0.012	0.703 [0.296, 1.669]	0.424	0.555 [0.200, 1.541]	0.258
Total Uninsurance rate	0.932 [0.850, 1.024]	0.141	1.025 [0.987, 1.065]	0.206	1.000 [0.961, 1.040]	0.988
Number of FQHC per 10,000 population below poverty level (in 1000s)	0.821 [0.544, 1.238]	0.346	0.996 [0.970, 1.022]	0.741	0.996 [0.971, 1.022]	0.749
% of population non-white	1.008 [0.976, 1.041]	0.640	0.993 [0.977, 1.009]	0.381	1.004 [0.988, 1.019]	0.651
Income per capita (in 1000s)	0.991 [0.949, 1.034]	0.678	-0.004 [-0.023, 0.015]	0.708	0.995 [0.976, 1.014]	0.602
Jurisdiction						
County/City-County	REF		REF		REF	
City/Township	-	-	0.252 [0.118, 0.539]	<0.001	0.257 [0.118, 0.563]	0.001
Other	1.408 [0.558, 3.558]	0.469	0.560 [0.271, 1.157]	0.117	0.873 [0.483, 1.581]	0.654
% of population unemployed	1.089 [0.930, 1.276]	0.290	0.899 [0.793, 1.019]	0.096	0.048 [-0.062, 0.158]	0.390
Hospital beds per 100,000 residents	0.999 [0.998, 1.000]	0.017	0.999[0.999, 1.000]	0.074	0.999 [0.999, 1.000]	0.133
Physicians per 100,000 residents	1.000 [0.999, 1.001]	0.924	0.999 [0.999, 0.999]	0.010	0.999 [0.999, 0.999]	0.004

REFERENCES

Aday, L. A., & Andersen, R. M. (1981). Equity of access to medical care: A conceptual and empirical overview. *Medical Care, 19*(12), 4-27.

Andersen, R., & Davidson, P. (2001). Improving access to care in America: Individual and contextual indicators. In R. Andersen, T. Rice & E. Kominski (Eds.), *Changing the U.S. health care system: Key issues in health services, policy, and management* (pp. 3-30). San Francisco, CA: Jossey-Bass.

Arduino, K. (2015). Rural hospitals: An asset in the continuum of care. *Healthcare Financial Management: Journal of the Healthcare Financial Management Association, 69*(11), 82-6, 88.

Ariizumi, H., & Schirle, T. (2012). Are recessions really good for your health? Evidence from Canada. *Social Science & Medicine (1982), 74*(8), 1224-1231. doi:10.1016/j.socscimed.2011.12.038 [doi]

ASTHO. (2014). *ASTHO profile of state public health, volume three.* Washington, DC: Association of State and Territorial Health Officials (ASTHO).

Baum, C. F., Schaffer, M. E., & Stillman, S. (2010). *Ivreg2: Stata module for extended instrumental variables/2SLS, GMM and AC/HAC, LIML and k-class regression.*

Beatty, K., Hale, N., Meit, M., Masters, P., & Khoury, A. (2016). Local health department clinical service delivery along the urban/rural continuum. *Frontiers in Public Health Services and Systems Research, 5*(1)

Behringer, B., Friedell, G., Dorgan, K., Hutson, S., Naney, C., Phillips, A., . . . Cantrell, E. (2007). Understanding the challenges of reducing cancer in Appalachia: Addressing a place-based health disparity population. *Californian Journal of Health Promotion, 5*, 40-49.

Berkowitz, B. (2004). Rural public health service delivery: Promising new directions. *American Journal of Public Health, 94*(10), 1678-1681. doi:94/10/1678 [pii]

Berkowitz, B., Ivory, J., & Morris, T. (2002). Rural public health: Policy and research opportunities. *The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association, 18 Suppl*, 186-196.

Black, D. A., Sanders, S. G., Taylor, E. J., & Taylor, L. J. (2015). The impact of the great migration on mortality of African Americans: Evidence from the Deep South. *The American Economic Review, 105*(2), 477-503. doi:10.1257/aer.20120642 [doi]

Blumenthal, S. J., & Kagen, J. (2002). MSJAMA. The effects of socioeconomic status on health in rural and urban America. *JAMA, 287*(1), 109. doi:jms0102-3 [pii]

Brigham and Women's Hospital. (2013). *Community health needs assessment report.* Boston, MA: Brigham and Women's Hospital.

BroMenn Medical Center, McLean County Health Department, OSF St. Joseph Medical Center, & United Way of McLean County. (2016). *Community health needs assessment.* McLean County, IL:

Burrows, E., Suh, R., & Hamann, D. (2003, Updated 2012). Updated version of health care workforce distribution and shortage issues in rural America. *National Rural Health Association Policy Brief,*

Caldwell, J., Ford, C., Wallace, S., Wang, M., & Takahashi, L. (2016). Intersection of living in a rural versus urban area and race/ethnicity in explaining access to health care in the United States. *American Journal of Public Health, 106*(8), 1463-1469. doi:10.2105/AJPH.2016.303212

CCLHO-CHEAC. (2013). *Chronic disease prevention framework.* CA: California Department of Public Health's Network for a Healthy California.

Centers for Disease Control and Prevention. (2014). *A public health action plan to prevent heart disease and stroke.* Atlanta, GA: US Department of Health and Human Services.

Centers for Disease Control and Prevention (CDC). (2003). Public health and aging: Hospitalizations for stroke among adults aged >/=65 years--United States, 2000. *MMWR. Morbidity and Mortality Weekly Report, 52*(25), 586-589. doi:mm5225a3 [pii]

Centers for Disease Control and Prevention (CDC). (2009). Prevalence and most common causes of disability among adults--United States, 2005. *MMWR. Morbidity and Mortality Weekly Report, 58*(16), 421-426. doi:mm5816a2 [pii]

Centers for Disease Control and Prevention (CDC). (2012a). Prevalence of stroke--United States, 2006-2010. *MMWR. Morbidity and Mortality Weekly Report, 61*(20), 379-382. doi:mm6120a5 [pii]

Centers for Disease Control and Prevention (CDC). (2012b). Vital signs: Awareness and treatment of uncontrolled hypertension among adults--united states, 2003-2010. *MMWR. Morbidity and Mortality Weekly Report, 61*, 703-709. doi:mm6135a3 [pii]

Centers for Disease Control and Prevention (CDC). (2014a). Preventing stroke: Other medical conditions. Retrieved from https://www.cdc.gov/stroke/medical_conditions.htm

Centers for Disease Control and Prevention (CDC). (2014b). The public health system and the 10 essential public health services. Retrieved from http://www.cdc.gov/nphpsp/essentialservices.html

Centers for Disease Control and Prevention (CDC). (2015a). Compressed mortality file 1999-2014 on CDC WONDER online database. Retrieved from http://wonder.cdc.gov/cmf-icd10.html

Centers for Disease Control and Prevention (CDC). (2015b). Interactive atlas of heart disease and stroke. Retrieved from https://www.cdc.gov/dhdsp/maps/atlas/index.htm

Centers for Disease Control and Prevention (U.S.), & United States, Congress, Senate, Committee on Appropriations. (2001). *Public health's infrastructure, A status report to the U.S. senate appropriations committee.* Washington, DC: U.S. Government Printing Office.

Centers for Disease Control and Prevention, National Center for Health Statistics. (2016). Compressed mortality file "1999-2014" on CDC WONDER online database. Retrieved from http://wonder.cdc.gov/cmf-icd10.html

Chetty, R., Stepner, M., Abraham, S., Lin, S., Scuderi, B., Turner, N., . . . Cutler, D. (2016). The association between income and life expectancy in the United States, 2001-2014. *JAMA, 315*(16), 1750-1766. doi:10.1001/jama.2016.4226 [doi]

Chowdhury, P. P., Mawokomatanda, T., Xu, F., Gamble, S., Flegel, D., Pierannunzi, C., . . . Town, M. (2016). Surveillance for certain health behaviors, chronic diseases, and

conditions, access to health care, and use of preventive health services among states and selected local areas- behavioral risk factor surveillance system, united states, 2012. *Morbidity and Mortality Weekly Report. Surveillance Summaries (Washington, D.C.: 2002), 65*(4), 1-142. doi:10.15585/mmwr.ss6504a1 [doi]

CMS. (2014). National health expenditures 2014.

Committee on The Future of Rural Health Care, Board on Health Care Services, & Institute of Medicine. (2005). *Quality through collaboration: The future of rural health care.* Washington, DC: The National Academies Press. doi:10.17226/11140

Crook, E. D., & Peters, M. (2008). Health disparities in chronic diseases: Where the money is. *The American Journal of the Medical Sciences, 335*(4), 266-270. doi:S0002-9629(15)32323-5 [pii]

Crosby, R. A., Wndel, M. L., Vanderpool, R. C., & Casey, B. R. (Eds.). (2012). *Rural populations and health: Determinants, disparities, and solutions* (1st ed.). San Francisco, CA: Jossey-Bass.

Dranove, D., & Satterthwaite, M. A. (2000). The industrial organization of health care markets. In A. J. Culyer, & J. P. Newhouse (Eds.), *Handbook of health economics (vol. 1)* North Holland: Elsevier.

Eberhardt, M., Ingram, D., Makuc, D., & et al. (2001). *Urban and rural health chartbook. Health, United States, 2001*. Hyattsville, Maryland: National Center for Health Statistics.

Eisenhauer, C. M., & Meit, M. (2016). Rural public health. *National Rural Health Association Policy Brief,*

Farahani, M., Subramanian, S. V., & Canning, D. (2009). The effect of changes in health sector resources on infant mortality in the short-run and the long-run: A longitudinal econometric analysis. *Social Science & Medicine (1982), 68*(11), 1918-1925. doi:10.1016/j.socscimed.2009.03.023 [doi]

Fielding, J. E., Teutsch, S., & Breslow, L. (2010). A framework for public health in the United States. *Public Health Reviews, 32*(1), 174-89.

Foot, D. K., Lewis, R. P., Pearson, T. A., & Beller, G. A. (2000). Demographics and cardiology, 1950-2050. *Journal of the American College of Cardiology, 35*(4), 1067-1081. doi:S0735-1097(00)00561-1 [pii]

Fordyce, M., Chen, F., Doescher, M., & Hart, L. (2007). *2005 physician supply and distribution in rural areas of the United States.* (No. 116). Washington: University of Washington Rural Health Research Center.

Gable, L. (2011). The patient protection and affordable care act, public health, and the elusive target of human rights. *The Journal of Law, Medicine & Ethics: A Journal of the American Society of Law, Medicine & Ethics, 39*(3), 340-354. doi:10.1111/j.1748-720X.2011.00604.x [doi]

Greenville Health System. (2013). *Community health needs assessment.* Greenville County, SC: Greenville Health System.

Hale, N. (2015). *Rural public health systems: Challenges and opportunities for improving population health.* AcademyHealth.

Hale, N. L., Klaiman, T., Beatty, K. E., & Meit, M. B. (2016). Local health departments as clinical safety net in rural communities. *American Journal of Preventive Medicine,* doi:S0749-3797(16)30182-9 [pii]

Hall, M. J., Levant, S., & DeFrances, C. J. (2012). Hospitalization for stroke in U.S. hospitals, 1989-2009. *NCHS Data Brief, (95)*(95), 1-8.

Handler, A., Issel, M., & Turnock, B. (2001). A conceptual framework to measure performance of the public health system. *American Journal of Public Health, 91*(8), 1235-1239.

Hanley, J. A., Negassa, A., Edwardes, M. D., & Forrester, J. E. (2003). Statistical analysis of correlated data using generalized estimating equations: An orientation. *American Journal of Epidemiology, 157*(4), 364-375.

Harris, J. K., Beatty, K., Leider, J. P., Knudson, A., Anderson, B. L., & Meit, M. (2016). The double disparity facing rural local health departments. *Annual Review of Public Health, 37*, 167-184. doi:10.1146/annurev-publhealth-031914-122755 [doi]

Harris, J. K., & Mueller, N. L. (2013). Policy activity and policy adoption in rural, suburban, and urban local health departments. *Journal of Public Health Management and Practice: JPHMP, 19*(2), E1-8. doi:10.1097/PHH.0b013e318252ee8c [doi]

Hawk, W., & Consumer Expenditure Program. (2013). Expenditures of urban and rural households in 2011. *U.S. Bureau of Labor Statistics- Beyond the Numbers: Prices & Spending, 2*(5)

Himmelstein, D. U., & Woolhandler, S. (2016). Public health's falling share of US health spending. *American Journal of Public Health, 106*(1), 56-57. doi:10.2105/AJPH.2015.302908 [doi]

Hines, F., Brown, D., & Zimmer, J. (1975). *Social and economic characteristics of the population in metro and nonmetro counties, 1970.* (No. Agricultural Economic Report # 272).Economic Research Service, U.S. Department of Agriculture.

Hogg, R. A., Mays, G. P., & Mamaril, C. B. (2015). Hospital contributions to the delivery of public health activities in US metropolitan areas: National and longitudinal trends. *American Journal of Public Health, 105*(8), 1646-1652. doi:10.2105/AJPH.2015.302563 [doi]

Hurley, L. P., Dickinson, L. M., Estacio, R. O., Steiner, J. F., & Havranek, E. P. (2010). Prediction of cardiovascular death in racial/ethnic minorities using Framingham risk factors. *Circulation.Cardiovascular Quality and Outcomes, 3*(2), 181-187. doi:10.1161/CIRCOUTCOMES.108.831073 [doi]

Ingram, R. C., Scutchfield, F. D., Mays, G. P., & Bhandari, M. W. (2012). The economic, institutional, and political determinants of public health delivery system structures. *Public Health Reports (Washington, D.C.: 1974), 127*(2), 208-215.

Institute of Medicine. (1988). *The future of public health.* Washington, DC: National Academy Press.

Institute of Medicine. (2002). *The future of the public's health in the 21st century.* Washington, DC: National Academy Press.

Institute of Medicine. (2012). *For the public's health: Investing in a healthier future.* Washington, DC: The National Academies Press.

IOM (Institute of Medicine). (2010). *A population-based policy and systems change approach to prevent and control hypertension.* Washington, DC: The National Academies Press.

Kaiser Family Foundation. (2016). *Fact sheet: Key facts about the uninsured population.* Menlo Park, CA: The Keiser Commission on Medicaid and the Uninsured.

Karwalajtys, T., & Kaczorowski, J. (2010). An integrated approach to preventing cardiovascular disease: Community-based approaches, health system initiatives, and public health policy. *Risk Management and Healthcare Policy, 3*, 39-48. doi:10.2147/RMHP.S7528 [doi]

Kaufman, B. G., Thomas, S. R., Randolph, R. K., Perry, J. R., Thompson, K. W., Holmes, G. M., & Pink, G. H. (2016). The rising rate of rural hospital closures. *The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association, 32*(1), 35-43. doi:10.1111/jrh.12128 [doi]

Kenkel, D. (2000). Prevention. In A. Cuyler, & J. Newhouse (Eds.), *Handbook of health economics* (pp. 1675-1720) North-Holland.

Kindig, D., & Stoddart, G. (2003). What is population health? *American Journal of Public Health, 93*(3), 380-383.

Kochanek, K., Xu, J., Murphy, S., & Arias, E. (2014). *Mortality in the United States, 2013. NCHS data brief, no. 178.* Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control and Prevention, US Dept. of Health and Human Services.

Koh, H. K., Blakey, C. R., & Roper, A. Y. (2014). Healthy people 2020: A report card on the health of the nation. *JAMA, 311*(24), 2475-2476. doi:1876599 [pii]

Koh, H. K., Piotrowski, J. J., Kumanyika, S., & Fielding, J. E. (2011). Healthy people: A 2020 vision for the social determinants approach. *Health Education & Behavior: The Official Publication of the Society for Public Health Education, 38*(6), 551-557. doi:10.1177/1090198111428646 [doi]

Larson, E., Johnson, K., Norris, T., Lishner, D., Rosenblatt, R., & Hart, L. (2003). *State of the health workforce in rural America, profiles and comparisons.* Seattle, WA: WWAMI Rural Health Research Center.

Lawrence, R. S. (1990). The role of physicians in promoting health. *Health Affairs (Project Hope), 9*(2), 122-132.

Liff, J. M., Chow, W. H., & Greenberg, R. S. (1991). Rural-urban differences in stage at diagnosis. Possible relationship to cancer screening. *Cancer, 67*(5), 1454-1459.

Lillrank, P., Groop, P. J., & Malmstrom, T. J. (2010). Demand and supply-based operating modes--a framework for analyzing health care service production. *The Milbank Quarterly, 88*(4), 595-615. doi:10.1111/j.1468-0009.2010.00613.x [doi]

Ma, J., Ward, E. M., Siegel, R. L., & Jemal, A. (2015). Temporal trends in mortality in the United States, 1969-2013. *JAMA, 314*(16), 1731-1739. doi:10.1001/jama.2015.12319 [doi]

Manton, K. G., Gu, X. L., Lowrimore, G., Ullian, A., & Tolley, H. D. (2009). NIH funding trajectories and their correlations with US health dynamics from 1950 to 2004. *Proceedings of the National Academy of Sciences of the United States of America, 106*(27), 10981-10986. doi:10.1073/pnas.0905104106 [doi]

Mays, G. P., & Mamaril, C. B. (2015, 6/03/2015). Changes in public health system capital and long-run health and economic outcomes- 1998 to 2014. Retrieved from http://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1080&context=hsm_present

Mays, G. P., Halverson, P. K., Baker, E. L., Stevens, R., & Vann, J. J. (2004a). Availability and perceived effectiveness of public health activities in the nation's

most populous communities. *American Journal of Public Health, 94*(6), 1019-1026. doi:94/6/1019 [pii]

Mays, G. P., Halverson, P. K., Baker, E. L., Stevens, R., & Vann, J. J. (2004b). Availability and perceived effectiveness of public health activities in the nation's most populous communities. *American Journal of Public Health, 94*(6), 1019-1026. doi:94/6/1019 [pii]

Mays, G. P., Halverson, P. K., & Kaluzny, A. D. (1998). Collaboration to improve community health: Trends and alternative models. *The Joint Commission Journal on Quality Improvement, 24*(10), 518-540.

Mays, G. P., Halverson, P. K., Kaluzny, A. D., & Norton, E. C. (2000). How managed care plans contribute to public health practice. *Inquiry: A Journal of Medical Care Organization, Provision and Financing, 37*(4), 389-410.

Mays, G. P., & Hogg, R. A. (2015). Economic shocks and public health protections in US metropolitan areas. *American Journal of Public Health, 105 Suppl 2*, S280-7. doi:10.2105/AJPH.2014.302456 [doi]

Mays, G. P., Mamaril, C. B., & Timsina, L. R. (2016a). Preventable death rates fell where communities expanded population health activities through multisector networks. *Health Affairs (Project Hope), 35*(11), 2005-2013. doi:35/11/2005 [pii]

Mays, G. P., Mamaril, C. B., & Timsina, L. R. (2016b). Preventable death rates fell where communities expanded population health activities through multisector networks. *Health Affairs (Project Hope), 35*(11), 2005-2013. doi:35/11/2005 [pii]

Mays, G. P., McHugh, M. C., Shim, K., Perry, N., Lenaway, D., Halverson, P. K., & Moonesinghe, R. (2006). Institutional and economic determinants of public health system performance. *American Journal of Public Health, 96*(3), 523-531. doi:AJPH.2005.064253 [pii]

Mays, G. P., Scutchfield, F. D., Bhandari, M. W., & Smith, S. A. (2010). Understanding the organization of public health delivery systems: An empirical typology. *The Milbank Quarterly, 88*(1), 81-111. doi:10.1111/j.1468-0009.2010.00590.x [doi]

Mays, G. P., & Smith, S. A. (2009). Geographic variation in public health spending: Correlates and consequences. *Health Services Research, 44*(5 Pt 2), 1796-1817. doi:10.1111/j.1475-6773.2009.01014.x [doi]

Mays, G. P., & Smith, S. A. (2011). Evidence links increases in public health spending to declines in preventable deaths. *Health Affairs (Project Hope), 30*(8), 1585-1593. doi:10.1377/hlthaff.2011.0196 [doi]

Mays, G. P., Smith, S. A., Ingram, R. C., Racster, L. J., Lamberth, C. D., & Lovely, E. S. (2009). Public health delivery systems: Evidence, uncertainty, and emerging research needs. *American Journal of Preventive Medicine, 36*(3), 256-265. doi:10.1016/j.amepre.2008.11.008 [doi]

McCullough, J. M., & Leider, J. P. (2016). Government spending in health and nonhealth sectors associated with improvement in county health rankings. *Health Affairs (Project Hope), 35*(11), 2037-2043. doi:35/11/2037 [pii]

McLaughlin, D. K., & Stokes, C. S. (2002). Income inequality and mortality in US counties: Does minority racial concentration matter? *American Journal of Public Health, 92*(1), 99-104.

McMichael, A. J., & Butler, C. D. (2006). Emerging health issues: The widening challenge for population health promotion. *Health Promotion International, 21 Suppl 1*, 15-24. doi:21/suppl_1/15 [pii]

Meit, M., Knudson, A., Gilbert, T., Yu, A. T., Tanenbaum, E., Ormson, E., . . . NORC Walsh Center for Rural Health Analysis. (2014). *The 2014 update of the rural-urban chartbook.* Bethesda, MD: Rural Health Reform Policy Research Center.

Mendis, S., Puska, P., & Norrving, B. (Eds.). (2011). *Global atlas on cardiovascular disease prevention and control*. Geneva: World Health Organization.

Miller, C. A., Moore, K. S., Richards, T. B., & McKaig, C. (1994). A screening survey to assess local public health performance. *Public Health Reports (Washington, D.C.: 1974), 109*(5), 659-664.

Miller, C. A., Moore, K. S., Richards, T. B., & Monk, J. D. (1994a). A proposed method for assessing the performance of local public health functions and practices. *American Journal of Public Health, 84*(11), 1743-1749.

Miller, C. A., Moore, K. S., Richards, T. B., & Monk, J. D. (1994b). A proposed method for assessing the performance of local public health functions and practices. *American Journal of Public Health, 84*(11), 1743-1749.

Miller, C. A., Richards, T. B., Davis, S. M., McKaig, C. A., Koch, G. G., Sharp, T. J., & Christenson, G. M. (1995a). Validation of a screening survey to assess local public health performance. *Journal of Public Health Management and Practice: JPHMP, 1*(1), 63-71.

Miller, C. A., Richards, T. B., Davis, S. M., McKaig, C. A., Koch, G. G., Sharp, T. J., & Christenson, G. M. (1995b). Validation of a screening survey to assess local public health performance. *Journal of Public Health Management and Practice: JPHMP, 1*(1), 63-71.

Moulton, A. D., Halverson, P. K., Honore, P. A., & Berkowitz, B. (2004). Public health finance: A conceptual framework. *Journal of Public Health Management and Practice: JPHMP, 10*(5), 377-382.

Mozaffarian, D., Benjamin, E. J., Go, A. S., Arnett, D. K., Blaha, M. J., Cushman, M., . . . Stroke Statistics Subcommittee. (2016). Heart disease and stroke statistics-2016 update: A report from the American Heart Association. *Circulation, 133*(4), e38-360. doi:10.1161/CIR.0000000000000350 [doi]

Mozzafarian, D., Benjamin, E. J., Go, A. S., & et, a. (2015). Heart disease and stroke statistics--2015 update: A report from the American Heart Association. *Circulation, 131*(4), e29-322. doi:10.1161/CIR.0000000000000219 [doi]

Murphy SL, Kochanek KD, Xu JQ, Heron M. Deaths: Final data for 2012. (2015). National vital statistics reports; 63(9). Hyattsville, MD: National Center for Health Statistics.

Murray, C. J., Atkinson, C., Bhalla, K., Birbeck, G., Burstein, R., Chou, D., . . . U.S. Burden of Disease Collaborators. (2013). The state of US health, 1990-2010: Burden of diseases, injuries, and risk factors. *JAMA, 310*(6), 591-608. doi:10.1001/jama.2013.13805 [doi]

National Advisory Committee on Rural Health and Human Services (NACRHHS). (2008). *The 2008 report to the secretary: Rural health and human services issues.* U.S. Department of Health and Human Services.

National Collaborating Centre for Methods and Tools. (2012). A model for evidence-informed decision making in public health [fact sheet]. Retrieved from http://www.nccmt.ca/uploads/media/media/0001/01/9e2175871f00e790a936193e98f4607313a58c84.pdf

National Opinion Research Center (NORC). (2008). *Rural public health agency accreditation, final report.* Bethesda, MD: National Opinion Research Center (NORC) Walsh Center for Rural Health Analysis.

National Research Council (US), Institute of Medicine (US). (2013). In Woolf S. H., Aron L. (Eds.), *U.S. health in international perspective: Shorter lives, poorer health*. Washington, DC: National Academies Press (US).

Newhouse, J. P., & McClellan, M. (1998). Econometrics in outcomes research: The use of instrumental variables. *Annual Review of Public Health, 19*, 17-34. doi:10.1146/annurev.publhealth.19.1.17 [doi]

Nord, M. (1999). Racial and spatial equity in welfare programs. Interstate and intercounty differences in welfare spending. *Rural Development Perspectives, 13*(3), 11-18.

OECD. (2014). OECD health statistics 2014-how does the United Kingdom compare? Retrieved from http://www.oecd.org/unitedkingdom/Briefing-Note-UNITED-KINGDOM-2014.pdf

OECD. (2015). *Health at a glance 2015: OECD indicators.* Paris: OECD Publishing.

Office of Rural Health Policy. (2005). *Mental health and rural America, 1994-2005: An overview and annotated bibliography.* S. Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy.

Pathman, D. E., Fryer, G. E., Green, L. A., & Phillips, R. L. (2005). Changes in age-adjusted mortality rates and disparities for rural physician shortage areas staffed by the National Health Service corps: 1984-1998. *The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association, 21*(3), 214-220.

Pennant, M., Davenport, C., Bayliss, S., Greenheld, W., Marshall, T., & Hyde, C. (2010). Community programs for the prevention of cardiovascular disease: A systematic review. *American Journal of Epidemiology, 172*(5), 501-516. doi:10.1093/aje/kwq171 [doi]

Pezzino, G., Libbey, P., & Nicola, B. (2014). Cross-jurisdictional approaches to meeting PHAB standards and achieving accreditation. *Journal of Public Health Management and Practice: JPHMP, 20*(1), 138-140. doi:10.1097/PHH.0b013e3182a7bd91 [doi]

Pomeranz, J. L. (2011). The unique authority of state and local health departments to address obesity. *American Journal of Public Health, 101*(7), 1192-1197. doi:10.2105/AJPH.2010.300023 [doi]

Probst, J. C., Moore, C. G., Glover, S. H., & Samuels, M. E. (2004). Person and place: The compounding effects of race/ethnicity and rurality on health. *American Journal of Public Health, 94*(10), 1695-1703. doi:94/10/1695 [pii]

Reeve, B. B., Burke, L. B., Chiang, Y. P., Clauser, S. B., Colpe, L. J., Elias, J. W., . . . Werner, E. M. (2007). Enhancing measurement in health outcomes research supported by agencies within the US department of health and human services. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation, 16 Suppl 1*, 175-186. doi:10.1007/s11136-007-9190-8 [doi]

Revicki, D. A., & Regulatory Issues and Patient-Reported Outcomes Task Force for the International Society for Quality of Life Research. (2007). FDA draft guidance and health-outcomes research. *Lancet (London, England), 369*(9561), 540-542. doi:S0140-6736(07)60250-5 [pii]

Reynolds, S. L., Hagedorn, A., Yeom, J., Saito, Y., Yokoyama, E., & Crimmins, E. M. (2008). A tale of two countries--the United States and japan: Are differences in health due to differences in overweight? *Journal of Epidemiology, 18*(6), 280-290. doi:JST.JSTAGE/jea/JE2008012 [pii]

Richards, T. B., Rogers, J. J., Christenson, G. M., Miller, C. A., Taylor, M. S., & Cooper, A. D. (1995). Evaluating local public health performance at a community level on a statewide basis. *Journal of Public Health Management and Practice: JPHMP, 1*(4), 70-83.

Ricketts, T. C., & Holmes, G. M. (2007). Mortality and physician supply: Does region hold the key to the paradox? *Health Services Research, 42*(6 Pt 1), 2233-51; discussion 2294-323. doi:HESR728 [pii]

Robert Wood Johnson Foundation. (2016). *From vision to action: A framework and measures to mobilize a culture of health.* NY: RWJF.

Rodriguez, H. P., Chen, J., Owusu-Edusei, K., Suh, A., & Bekemeier, B. (2012). Local public health systems and the incidence of sexually transmitted diseases. *American Journal of Public Health, 102*(9), 1773-1781. doi:10.2105/AJPH.2011.300497 [doi]

Royston, P., & Sauerbrei, W. (2004). A new approach to modelling interactions between treatment and continuous covariates in clinical trials by using fractional polynomials. *Statistics in Medicine, 23*(16), 2509-2525. doi:10.1002/sim.1815 [doi]

Rubinstein, A., Garcia Marti, S., Souto, A., Ferrante, D., & Augustovski, F. (2009). Generalized cost-effectiveness analysis of a package of interventions to reduce cardiovascular disease in buenos aires, argentina. *Cost Effectiveness and Resource Allocation: C/E, 7*, 10-7547-7-10. doi:10.1186/1478-7547-7-10 [doi]

Schaffer, M. E. (2010). *Xtivreg2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models*

Scutchfield, F. D., Hiltabiddle, S. E., Rawding, N., & Violante, T. (1997). Compliance with the recommendations of the institute of medicine report, the future of public health: A survey of local health departments. *Journal of Public Health Policy, 18*(2), 155-166.

Shak, L., Swartz, L., & Rivera, D. (2013). Championing change - elected officials act locally to make their communities healthier. *Policy Briefs of Prevention Institute and American Public Health Association,*

Shi, L., Tsai, J., & Kao, S. (2009). Public health, social determinants of health, and public policy. *Journal of Medical Science, 29*(2), 043-059.

Shi, L., Macinko, J., Starfield, B., Politzer, R., & Xu, J. (2005). Primary care, race, and mortality in US states. *Social Science & Medicine (1982), 61*(1), 65-75. doi:S0277-9536(04)00600-8 [pii]

Shore, K. (2007). *Understanding the United States public health system (policy brief).* CA: California Health Policy Forum.

Sinclair, A., & Whitford, A. (2015). Effects of participation and collaboration on perceived effectiveness of core public health functions. *American Journal of Public Health, 105*(8), 1638-1645. doi:10.2105/AJPH.2015.302586 [doi]

Singh, G. K., & Siahpush, M. (2014). Widening rural-urban disparities in life expectancy, U.S., 1969-2009. *American Journal of Preventive Medicine, 46*(2), e19-29. doi:10.1016/j.amepre.2013.10.017 [doi]

Smith, A. D., & Taylor, J. E. (2016). *Essentials of applied econometrics*. Oakland, CA: University of California Press.

Smith, K. B., Humphreys, J. S., & Wilson, M. G. (2008). Addressing the health disadvantage of rural populations: How does epidemiological evidence inform rural health policies and research? *The Australian Journal of Rural Health, 16*(2), 56-66. doi:10.1111/j.1440-1584.2008.00953.x [doi]

Smith, S. A., Mays, G. P., Felix, H. C., Tilford, J. M., Curran, G. M., & Preston, M. A. (2015). Impact of economic constraints on public health delivery systems structures. *American Journal of Public Health, 105*(9), e48-53. doi:10.2105/AJPH.2015.302769 [doi]

Special Service for Groups. (2013). *Community health needs assessment.* CA: Kaiser Foundation Hospital - Riverside.

Stamatakis, K. A., Lewis, M., Khoong, E. C., & Lasee, C. (2014). State practitioner insights into local public health challenges and opportunities in obesity prevention: A qualitative study. *Preventing Chronic Disease, 11*, E39. doi:10.5888/pcd11.130260 [doi]

Starfield, B., Shi, L., Grover, A., & Macinko, J. (2005). The effects of specialist supply on populations' health: Assessing the evidence. *Health Affairs (Project Hope), Suppl Web Exclusives*, W5-97-W5-107. doi:hlthaff.w5.97 [pii]

Systems for Action National Program Office. (2015). *Research agenda-delivery and financing system innovations for a culture of health.* Lexington, KY: University of Kentucky.

The Rural Health Information Hub. (2014). Rural health policy. Retrieved from https://www.ruralhealthinfo.org/topics/rural-health-policy

The Rural Health Information Hub. (2015). What is rural? Retrieved from https://www.ruralhealthinfo.org/topics/what-is-rural

Trogdon, J. G., Finkelstein, E. A., Nwaise, I. A., Tangka, F. K., & Orenstein, D. (2007). The economic burden of chronic cardiovascular disease for major insurers. *Health Promotion Practice, 8*(3), 234-242. doi:8/3/234 [pii]

Trust for America's Health. (2013). *Investing in America's health: A state-by-state look at public health funding and key health facts.* Washington, DC: Trust for America's Health.

Turnock, B. J. (2004). The infrastructure of public health. *Public health: What it is and how it works* (3rd ed., pp. 223-73). Sudbury, MA: Jones and Bartlett Publishers.

Turnock, B. J. (2001). *Public Health—What it is and how it works* (2nd ed.). Gaithersburg, MD: Aspen Publishers.

Turnock, B. J., Handler, A., Hall, W., Potsic, S., Nalluri, R., & Vaughn, E. H. (1994). Local health department effectiveness in addressing the core functions of public health. *Public Health Reports (Washington, D.C.: 1974), 109*(5), 653-658.

Turnock, B. J., Handler, A. S., & Miller, C. A. (1998). Core function-related local public health practice effectiveness. *Journal of Public Health Management and Practice: JPHMP, 4*(5), 26-32.

U.S. Centers for Disease Control and Prevention. (2013). *Community health assessment for population health improvement: Resource of most frequently recommended health outcomes and determinants.* Atlanta, GA: Office of Surveillance, Epidemiology, and Laboratory Services.

U.S. Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy. (2006). *Comparison of the rural health clinic and federally qualified health center programs.* Sterling, VA: U.S. Department of Health and Human Services, Health Resources and Services Administration, Office of Rural Health Policy.

USDA-ERS. (2016a). Rural-Urban Continuum Codes retrieved from https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/ on November 15, 2016

USDA-ERS. (2016b). What is Rural? retrieved from https://www.ers.usda.gov/topics/rural-economy-population/rural-classifications/what-is-rural/ on November 15, 2016

UPMC Passavant. (2013). *Community health needs assessment and community health strategic plan.* North Hills of Pittsburgh, Pennsylvania: UPMC Passavant.

Veazie, M. A., Galloway, J. M., Matson-Koffman, D., LaBarthe, D. R., Brownstein, J. N., Emr, M., . . . American Heart Association. (2005). Taking the initiative: Implementing the american heart association guide for improving cardiovascular health at the community level: Healthy people 2010 heart disease and stroke partnership community guideline implementation and best practices workgroup. *Circulation, 112*(16), 2538-2554. doi:112/16/2538 [pii]

Weaver, K. E., Palmer, N., Lu, L., Case, L. D., & Geiger, A. M. (2013). Rural-urban differences in health behaviors and implications for health status among US cancer survivors. *Cancer Causes & Control: CCC, 24*(8), 1481-1490. doi:10.1007/s10552-013-0225-x [doi]

WHO. (2012). *Note by the secretary-general transmitting the report of the director-general of the world he alth organization on options for strengthening and facilitating multisectoral action for the prevention and control of non-communicable diseases through effective partnership.* (No. A/67/373). Geneva: United Nations: General Assembly.

Wholey, D. R., Gregg, W., & Moscovice, I. (2009). Public health systems: A social networks perspective. *Health Services Research, 44*(5 Pt 2), 1842-1862. doi:10.1111/j.1475-6773.2009.01011.x [doi]

Wilson, I. B., & Cleary, P. D. (1995). Linking clinical variables with health-related quality of life. A conceptual model of patient outcomes. *JAMA, 273*(1), 59-65.

Winterbauer, N. L., Rafferty, A. P., Tucker, A., Jones, K., & Tucker-McLaughlin, M. (2016). Use and perceived impact of the county health rankings report in Florida and North Carolina. *Journal of Public Health Management and Practice: JPHMP, 22*(6), E1-7. doi:10.1097/PHH.0000000000000320 [doi]

Zeger, S. L., & Liang, K. Y. (1986). Longitudinal data analysis for discrete and continuous outcomes. *Biometrics, 42*(1), 121-130.

VITA

Lava Raj Timsina, MPH

EDUCATION

Year	Course
2010	Masters in Public Health, University of Nebraska Medical Center (UNMC), Omaha, NE
2003	Bachelor's Degree in Public Health from TU, Nepal
1998	10+2 in Science from HSEB, Nepal
1996	School Leaving Certificate from S.L.C. Board, Nepal

PUBLICATIONS IN PEER-REVIEWED JOURNALS

1. Mays, GP., Mamaril, CB., & **Timsina, LR**. (2016). Preventable death rates fell where communities expanded population health activities through multisector networks. *Health Affairs, 35*(11), 2005-2013. doi:35/11/2005 [pii]

2. Rabarison KM, **Timsina LR**, Mays GP. 2015 "Community Health Assessment and Improved Public Health Decision-Making: A Propensity Score Matching Approach" *Am J Public Health.* 105(12):2526-33.

3. Carman AL, **Timsina LR.** 2015. "Public health accreditation: rubber stamp or roadmap for improvement". *Am J Public Health* 105 Suppl 2: S353-9

4. Carman AL, **Timsina LR**, Scutchfield D. 2014. "Quality Improvement Activities of Local Health Departments during the 2008-2010 Economic Recession". *Am J Prev Med.* 46(2):171-4

5. Consortium from Altarum Institute, Centers for Disease Control and Prevention, Robert Wood Johnson Foundation, National Coordinating Center for Public Health Services and Systems Research. 2012. "A national research agenda for public health services and systems". *Am J Prev Med.* 42(5 Suppl 1):S72-8.

6. Singh GK, Siahpush M, Hiatt RA, **Timsina LR**. 2011. "Dramatic Increases in Obesity and Overweight Prevalence and Body Mass Index among Ethnic-Immigrant and Social Class Groups in the United States, 1976-2008". *J Community Health.* 36: 94-110. doi: 10.1007/s10900-010-9287-9.

7. Siahpush M, Jones PR, Singh GK, **Timsina LR**, Martin J. 2010. "Association of availability of tobacco products with socioeconomic and racial/ethnic characteristics of neighborhoods". *Public Health.* 124(9): 525-9.

8. Siahpush M, Jones PR, Singh GK, **Timsina LR**, Martin J. 2010. "The Association of Tobacco Marketing with Median Income and Racial/Ethnic Characteristics of Neighbourhoods in Omaha, Nebraska". *Tob Control.* 19(3):256-258.

9. Siahpush M, Singh GK, Jones PR, **Timsina LR**. 2009. "Racial/ethnic and socioeconomic variations in duration of smoking: Results from 2003, 2006, and 2007 Tobacco Use Supplement of the Current Population Survey". *J Public Health.* 32(2): 210-8. doi:10.1093/pubmed/fdp104.

SUBMITTED MANUSCRIPT

1. Costich J, Mays GP, **Timsina LR**, "How do laws influence tobacco control practice? Findings from the MPROVE network". *J of Tobacco Regulatory Science*
2. **Timsina LR**, Joanna W, Courtney T, Wellman H, Lombardi D, Brennan M, Verma S. "Circumstances of medically attended fall related injuries among U.S. adults by age and gender: A Narrative text analysis from the National Health Interview Survey 1997-2010". *PLOS ONE.*

MANUSCRIPT IN PROGRESS

1. **Timsina LR**, Mays GP, Hogg R, Mamaril CB, Ingram R. 2016. "Public Health Performance of Local Health Department: Do Rural Urban Characteristics Really Matter?"

2. **Timsina LR**, Siahpush M, Singh GK. "Dual use of tobacco (smoking cigarettes and use of smokeless tobacco) and intention to quit smoking among adult smokers: Results from Tobacco Use Supplement to Current Population Survey (TUS-CPS) 2006/2007".

3. **Timsina LR**, Watanabe-Galloway S, O'Keefe A. "Imipenem Resistant Multidrug Resistant Acinetobacter in Douglas County, Nebraska: a cross-sectional study"

4. **Timsina LR**, Siahpush M, Jones PR. "Intention to quit, attempt to quit, and use of cessation services to quit smoking among single mothers in the US"

5. **Timsina LR**, Siahpush M, Jones PR. "Smoking among single mothers: Results from Tobacco Use Supplement to Current Population Survey 2006-2007".

PROFESSIONAL REPORT PUBLICATIONS

1. UK Center for Public Health System and Services Research. (2015). National Longitudinal Survey of Local Public Health System – 2014 Customized Reports of Survey Results (The reports were created using automation in Excel VBA)

2. National Coordinating Center for Public Health Services and Systems Research. (2014). Multi-network Practice & Outcome Variation Examination Study - 2013 Customized Report of Survey Results (The reports were created using automation in Excel VBA)

3. National Coordinating Center for PHSSR (2013). *2013 PHSSR Keeneland Conference Evaluation Survey Report*. Lexington KY: National Coordinating Center for Public Health Services and Systems Research, College of Public Health , University of Kentucky.
    a. Quantitative analysis
    b. Qualitative analysis of the open-ended questions using NVivo 10.

4. Knight, EA., **Timsina, L**., Lamberth, CD., Louis, E., Knapp, D. (2012). *2012 Kentucky Public Health Workforce Assessment: Kentucky Professionals and Support Staff.* Lexington KY: Kentucky & Appalachia Public Health Training Center, College of Public Health, University of Kentucky.

5. Knight, EA., **Timsina, L**., Lamberth, CD., Louis, E. & Knapp, D. (2012). *2012 Kentucky Public Health Workforce Assessment: Kentucky Managers and Supervisors.* Lexington KY: Kentucky & Appalachia Public Health Training Center, College of Public Health, University of Kentucky.

6. Knight, EA., **Timsina, L**., Lamberth, CD., Louis, E., Knapp, D. (2012). *2012 Kentucky Public Health Workforce Assessment: Kentucky Directors and Senior Leaders.* Lexington KY: Kentucky & Appalachia Public Health Training Center, College of Public Health, University of Kentucky.

ONGOING RESEARCH PROJECTS

1. Wave 4 (completed) and Wave 5 (launched in July 2016) National Longitudinal Survey of Local Public Health System (designing online survey in REDCap, implementing the survey, and analyzing the data)
2. PHSSR Stakeholder's survey (designing online survey in REDCap, implementing the survey, and analyzing both quantitative and qualitative data)
3. PHSSR Annual Investigators Survey (designing online survey in REDCap, implementing the survey, and analyzing both quantitative and qualitative data)
4. CV analysis of research investigators funded through Robert Wood Johnson Foundation in PHSSR and PBRN using NVivo 10.
5. Longitudinal data analysis of Public Health Expenditure from 1974 through 1991 using the historical reports published by Public Health Foundation/Association of States and Territorial Health Officials.

BLOG PROJECTS

1. SAS Tutorial – Basics. This is an ongoing project and through this page of my blog I am targeting novice of SAS users to learn data analysis using the software in 10 days.

2. Stata Tutorial – A basic manual. This is a Stata manual for the novice Stata users and was created as a part of the Teaching Assistantship position for HPRO 805: Applied Research in Public Health at the University of Nebraska Medical Center in 2011.

WORK HISTORY

August 2011 – Current: **Graduate Research Assistant**

College of Public Health, University of Kentucky, Lexington KY

Responsibilities: Designing and collecting data using REDCap, an online survey tool; Cleaning data to import in SAS and Stata for analysis; Model based statistical imputation of missing data (if any); Providing advice to students and research team in study design and data analysis; Linking national level health determinants, outcomes, and claims data from different sources; Checking for any inconsistencies in data linkages; Writing manuscripts and submitting them for publications and presentations

May 2014-August 2014: **Research Fellow**

ASSE Foundation for the Safety Research Fellowship Program, Liberty Mutual Research Institute for Safety, Hopkinton, MA

Responsibilities: Designing, analyzing, and documenting a project to study circumstances of fall related injuries among adults in the US using National Health Interview Survey (1997-2010)

January 2011 – May 2011: **Teaching Assistant**

(HPRO 805: Advance Research in Public Health)
College of Public Health, UNMC, Omaha NE

Responsibilities: Helping the instructor in designing the teaching strategy, evaluation plan, and course materials; Grading assignments; Creating Stata manual for the students; Helping students in learning data processing and data management using Stata

January 2009 – December 2010: **Graduate Research Assistant**

College of Public Health, UNMC, Omaha NE

Responsibilities: Data processing and analysis using Stata; Literature reviews for manuscripts

June 2005 – September 2007: **District Health Coordinator**

CARE Nepal, Child Survival Project (CSP) XIX, Doti, Nepal

Responsibilities: Program planning, implementing, and monitoring the Child Survival Project activities at district level; Coordination and liaison with local non-governmental organizations, government and other stakeholders; Providing technical support to government health office at district and community level; Coordinate with partner non-governmental organizations in implementing child survival programs in the district; Coaching, mentoring, and training to manage human resources at district office.

March 2004 – May 2005: **HIV/AIDS Care and Support Officer**
Association of Medical Doctors of Asia (AMDA) Nepal, Safe Highway: Prevention to Care Project, Damak, Nepal

Responsibilities: Develop, implement, and supervise care & support programs to people with HIV/AIDS; Providing education, counseling, and training on HIV/AIDS and other sexually transmitted infections to help fight stigma and discrimination to people with HIV/AIDS and their families; Coordinate with partner non-governmental organizations in implementing care & support programs.

CONFERENCE PRESENTATIONS

1. **Timsina LR**, Joanna W, Courtney T, Wellman H, Lombardi D, Brennan M, Verma S. 2016. "Circumstances of Injury Causing Falls Among Community-dwelling U.S Adults by Age and Gender".Denver, CO. (poster)

2. Costich JF, **Timsina L**, Mays GP. 2016. Legal factors associated with public health practice variations in the multi-network practice and outcome variation examination study. AcademyHealth annual research meeting, Boston, MA. (poster)

3. **Timsina LR**, Mays GP, Hogg R, Mamaril CB, Ingram R. 2016. "Public Health Performance of Local Health Department: Do Rural Urban Characteristics Really Matter?". Academy Health Annual Research Meeting, Boston, MA. (oral)

4. **Timsina LR**, Mays GP, Hogg R, Mamaril CB, Ingram R. 2016. "Variability in the Availability and Perceived Effectiveness of Public Health Activities by Size and System Configurations of Public Health Jurisdiction: Results from 2014 National Longitudinal Survey of Public Health Systems". NACCHO Annual Conference, Phoenix, AZ (poster-accepted)

5. Costich JF, Mays GP, Bardach D, **Timsina L**. 2015. "Public health law findings from the multi-network practice and outcome variation examination study". Public Health Law Research Conference, San Juan PR. (poster)

6. Harper E, Costich J, **Timsina LR**, Scutchifield FD. 2013. "Tracking effect of Laws Governing State Public Health Agencies". Academy Health Annual Research Meeting, Baltimore, MD. (Poster)

7. Rabarison KM, **Timsina LR**, Scutchfield FD. Relationship between Population Level Health Outcomes and Collaborative Partnership of Local Health Departments and Hospitals. 2012 National Association of City and County Health Official Annual Conference, Los Angeles, CA. (Poster)

8. Rabarison KM, **Timsina LR**, Scutchfield FD. 2012. Relationship between Population Level Health Outcomes and Collaborative Partnership of Local Health Departments and Hospitals. 140th APHA Annual Meeting, San Francisco, CA. (Oral Presentation)

9. **Timsina LR**, Siahpush M, Singh GK. 2011. "Dual use of tobacco (smoking cigarettes and use of smokeless tobacco) and intention to quit smoking among adult smokers: Results from Tobacco Use Supplement to Current Population Survey (TUS-CPS) 2006/2007". 139th APHA Annual Meeting, Washington, DC (October 29 - November 2). (Poster)

10. Jones PR, Siahpush M, **Timsina LR**. 2010. "Association of clinical advice to quit smoking and intention to quit smoking". 138th APHA Annual Meeting, Denver, CO (Nov 6-10). (Poster)

11. Siahpush M, Jones PR, Singh GK, **Timsina LR**, Martin J. 2010. "Association of Tobacco Marketing with Median Income and Racial/Ethnic Characteristics of Neighbourhoods in Omaha, Nebraska". 138th APHA Annual Meeting, Denver, CO (Nov 6-10). (Poster)

12. **Timsina LR**, Siahpush M, Jones PR. 2010. "Intention to quit, attempt to quit, and use of cessation services to quit smoking among single mothers in the US". 138th APHA Annual Meeting, Denver, CO (Nov 6-10). (Poster)

13. **Timsina LR**, Siahpush M, Jones PR. 2010. "Smoking among single mothers: Results from Tobacco Use Supplement to Current Population Survey 2006-2007". 138th APHA Annual Meeting, Denver, CO (Nov 6-10). (Poster)

14. **Timsina LR**, Siahpush M, Jones PR. 2010. "Smoking Cessation Among Single Mothers: Results from Tobacco Use Supplement to Current Population Survey 2006-2007". National Association of Local Boards of Health (NALBOH) 18th Annual Conference, Omaha NE (August 5-7). (Poster)

15. Jones, PR., Siahpush M., Singh, G, **Timsina LR**, Martin, J. 2010. The association of availability of tobacco products with socioeconomic and racial/ethnic characteristics of neighborhoods. 2010 SRNT Annual Meeting, Baltimore, Maryland (February 24-27). (Poster)

16. Jones, PR., Siahpush M., Singh, G, **Timsina LR**, & Martin, J. 2010. The association of tobacco marketing with socioeconomic and racial/ethnic characteristics of neighborhoods.

Midwest Nursing Research Society 2010 Annual Research Conference, Kansas City, Kansas (April 8-11). (Poster)

17. **Timsina LR**, Pyakurel RS, Poudel D, Roy, K. 2007. "Child Survival Sustainability Assessment (CSSA) Framework". 12th Annual Child Survival Workshop, Nagpur, India (2007). (Oral Presentation)

INVITED PRESENTATIONS

1. **Timsina LR**. 2016. "Data visualization using Stata". CPH 647-001: Research Methods for Public Health, University of Kentucky, Lexington, KY (March 24, 2016).

2. **Timisina LR**. 2016 "Applied Sampling Techniques". EPI 714-001: Epidemiologic Study Design, University of Kentucky, Lexington, KY (March 2, 2016).

3. **Timsina LR**. 2014. "SAS-A Brief Introduction". CPH 954-001: Seminar on Advanced Public Health Finance and Economics, University of Kentucky, Lexington, KY (Sep 11, 2014).

4. **Timsina LR**. Rabarison K. 2012. "Analysis using Propensity Score Matching". CPH786-001: Doctoral Seminar, University of Kentucky, Lexington, KY (Sep 21, 2012).

5. **Timsina LR**, Siahpush M, Jones PR. 2010. "Intention to quit, attempt to quit, and use of cessation services to quit smoking among single mothers in the US". Department of Epidemiology Seminar, UNMC, Omaha, NE (Sep 14, 2010).

6. **Timsina LR**, Siahpush M, Jones PR. October 11, 2010. "Intention to quit, attempt to quit, and use of cessation services to quit smoking among single mothers in the US". Undergraduate course: ABA 907 Community applications of applied behavior analysis, University of Nebraska at Omaha, NE.

AWARDS RECEIVED

- Student Travel Support by College of Public Health, University of Kentucky, November 2016
- Student Travel Support by Graduate School Funding Office, University of Kentucky, July 2016
- Student Travel Support by Graduate School Funding Office, University of Kentucky, September 2011.
- Carruth J Wagner, MD Scholarships in Public Health. Awarded by University of Nebraska Medical Center, 2009-2011