MULTILEVEL FACTORS IMPACTING WORKFORCE COMPETENCE AND CAPACITY TO DELIVER PUBLIC HEALTH SERVICES

by

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CHAPTER I

Introduction

The public health system, an intersectoral system that comprises governmental public health agencies and various partners, including communities, the health care delivery system, employers and business, the media, and academia (IOM, 2003), is responsible for promoting and protecting population health. Over the past decade, greater emphasis has been placed on public health systems and services research (PHSSR), a public health counterpart to health systems research defined as "a field of study that examines the organization, financing, and delivery of public health services within a community and the impact of those services on public health" (Mays, Halverson, & Scutchfield, 2003; Scutchfield & Patrick, 2007), as a means for understanding how to improve the structure and function of the U.S. public health system.

PHSSR includes public health infrastructure studies among its areas of focus. Workforce capacity and competency, organizational capacity, and information/communication capacity are considered the foundation of public health infrastructure (Cioffi, Lichtveld & Tilson, 2004). Despite the importance of the public health workforce in delivering services to the population, little is known about its size, composition, demographics, and training and educational background (Beck & Boulton, 2012; Hilliard & Boulton, 2012). The most recent national enumeration study of the public health workforce estimated nearly 450,000 workers in dozens of occupational categories (Gebbie, Merrill, Hwang, Gebbie, & Gupta, 2003; HRSA, 2000). The study noted the challenges inherent in trying to define the public health workforce, including the breadth of job tasks and functions of workers, varying venues in which public health workers are employed, and inconsistencies in the use of job classifications throughout the public health system (Tilson & Gebbie, 2004). In 2012, a joint consortium of government, academic, and foundation partners developed a national research agenda for public health services and systems. The public health workforce was emphasized as a top research priority, with themes of enumeration; demand, supply and shortages; diversity and disparities; recruitment and retention; workforce competencies; and educational methods and curricula informing the development of research questions (Consortium, 2012).

Public Health Workforce Research

Public health workforce researchers have largely struggled to produce analytic findings to address the research areas underscored in the literature, in part due to the relatively limited funding available for PHSSR studies. Researchers interested in studying public health workforce factors have few data sets with which to work. Although workforce enumeration data for segments of the public health workforce, particularly state and local public health, have been collected periodically by a few national professional organizations, data describing characteristics of workers are scarce. Unlike other health professions, no national system for enumerating and tracking public health workers exists. The Bureau of Labor Statistics (BLS) within the U.S. Department of Labor collects continuous data on the nation's workforce; however, with few exceptions, the occupational and industry codes used in the BLS classification system are too general to apply to the public health workforce (UM/UK, 2012). Further, few public health professions require licensure or certification, adding to the challenge of establishing methods for systematic data collection.

Professional organizations representing public health workforce disciplines have taken the lead in collecting workforce data at the organizational and individual level. For example, the Council of State and Territorial Epidemiologists and Association of Public Health Laboratories have collected comprehensive workforce data within the last three years for epidemiologists and laboratorians, respectively. Although descriptive studies using these data have been published in peer reviewed and gray literature (Boulton, Hadler, Beck, Ferland, & Lichtveld, 2011; Beck, Boulton, Lemmings & Clayton, 2012; UM CEPHS/APHL, 2012), few empirical studies have been published. These data have limitations; for example, study findings may not be generalizable to the larger public health workforce, and survey instruments used by these organizations have not been psychometrically evaluated. However, they provide the most specificity of the few public health workforce data sets available so will be utilized in these dissertation studies to add to the PHSSR literature.

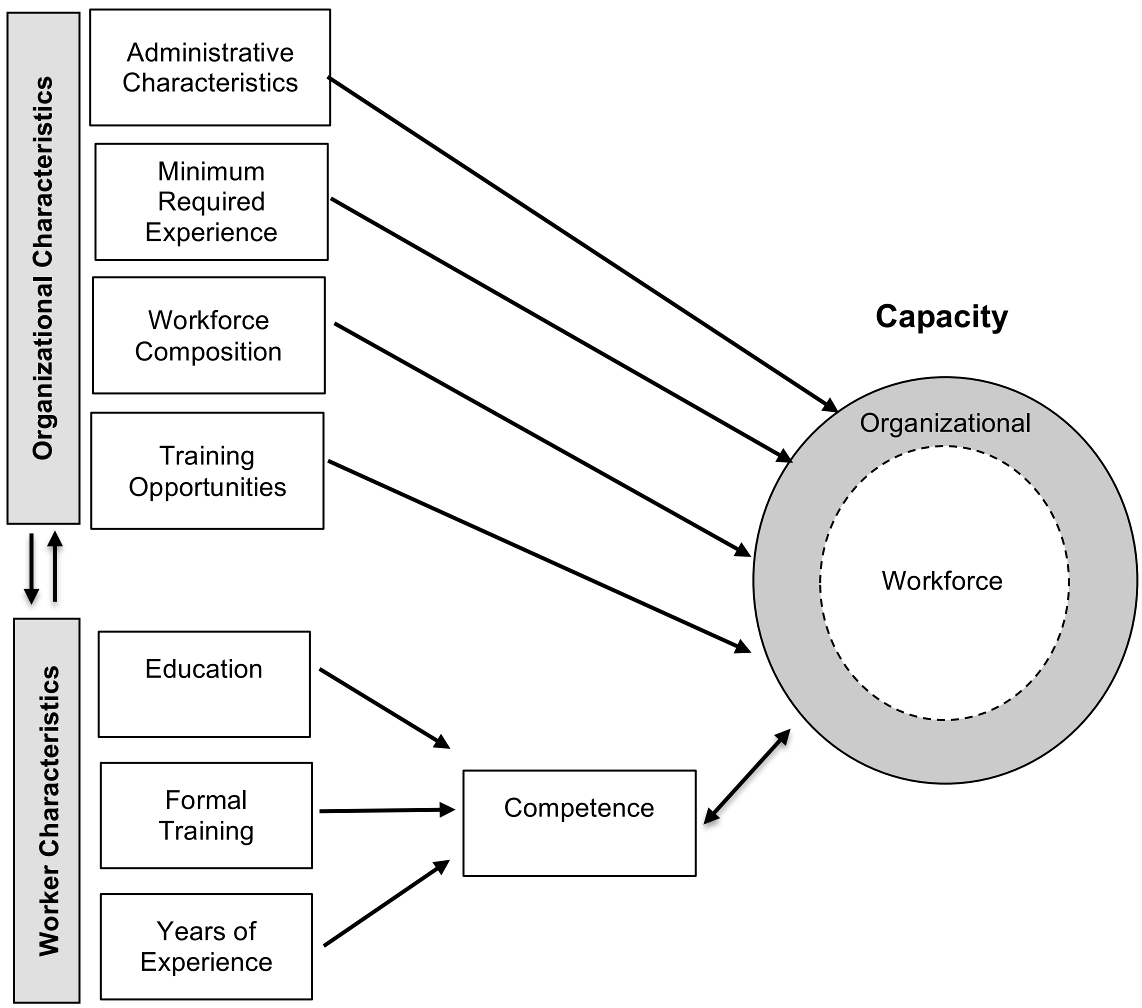
Theoretical Basis and Conceptual Model

This dissertation is primarily guided by the research agenda set forward for PHSSR, which informed the development of the conceptual model. Organizational development (OD) theory is a key framework supporting some of the pathways of the model. OD is typically used to enhance knowledge and effectiveness of people to improve organizational performance (Butterfoss, Kegler & Francisco, 2008). The framework is useful for characterizing an organization's design, technologies, use of human resources, environmental influences, and how its norms and values are transformed (Steckler, Goodman & Kegler, 2002). This theory is useful for this dissertation because of its focus on organizational capacity as a key construct of interest. Measures of organizational capacity may be used to identify an organization's strengths and weaknesses as part of program planning (Butterfoss et al., 2008).

Human capital theory, also highly relevant to the conceptual model, is an economic theory often applied to the field of education that broadly suggests that investments in workers result in economic benefits for individuals and society (Sweetland, 1996). Education is among the main investments examined as an asset in this theory. Studies suggest that education helps develop work skills, which improves the capacity of the worker to be productive (Benson, 1978; Sweetland, 1996). Theorists have suggested that formal education, work experience, and on-the-job training, all of which are included in the conceptual model, are critical measures of human capabilities and workforce capacities (Benson, 1978; Mincer, 1974; Schultz, 1971; Sweetland, 1996).

Figure 1.1 depicts the conceptual model that guides this dissertation research. The underlying premise of the model is that the organizational capacity of a public health organization to deliver public health services is influenced by the workforce it employs. The number, type, education, training, and competence of workers are hypothesized to vary across agencies. Identifying the key measures most strongly associated with developing a competent workforce, which may improve organizational capacity, could inform public health administrators about how to structure their agency's workforce to better achieve the mission of improved population health for all. The multilevel model presents several key constructs at workforce and organizational levels that are theorized to impact workforce and organizational capacity.

Figure 1.1. Conceptual model for dissertation



Capacity

Capacity is both an outcome of interest in Chapter IV and a potential predictor of worker competence in Chapter III. Organizational capacity has been defined as a "set of attributes that help or enable an organization to fulfill its missions" (Eisinger, 2002). In the context of this dissertation, organizational capacity refers to attributes at the organizational level that enable public health departments and laboratories to carry out Essential Public Health Services (EPHS) to improve health outcomes. Measurement of organizational capacity is examined in Chapter IV.

Similar to organizational capacity, workforce capacity refers to the ability of workers to collectively contribute toward an organization's mission. Workforce capacity can be considered a component of organizational capacity, in that the human resources of an organization are among its attributes that enable mission fulfillment. Studies explicitly defining how these two constructs interrelate have not been published, but the public health workforce literature broadly recognizes the importance of enhancing workforce capacity as a mechanism for improving the capacity of health departments and other public health organizations to deliver EPHS (Cioffi et al., 2004).

Organizational Characteristics

The model includes several organizational-level variables that describe health department characteristics. Among the variables hypothesized to be positively associated with organizational capacity are organizational policies regarding the minimum level of job experience required of workers prior to entry into the organization's workforce and the extent to which the organization supports employee professional development and continuing education. Additionally, the composition of the organization's workforce is theorized to impact organizational capacity. The workforce composition construct considers variables such as number of full-time equivalent workers employed by the organization, the proportion of workers employed in certain job classifications or tiers (i.e., entry-level, mid-level, senior management/scientist), the proportion of workers with prior years of relevant job experience, the proportion of workers educated at a bachelor's degree level or higher, and the proportion of workers with formal training in their discipline, which could be represented by an academic degree, fellowship, or other formal training (UM/UK, 2012; Novick, Morrow & Mays, 2008). Organizational characteristics may also refer to administrative or structural characteristics of an organization, such as its governance structure, which may be used as control variables in the dissertation studies.

Other organizational characteristics not specifically tested in the model due to lack of data, but may show promise in future research include: domains of leadership style; employee participation in organizational decision-making; the organizational mission and whether it supports capacity-building processes and procedures; support of diversity initiatives; shared values of the organization; and partnerships within departments that draw on expertise of multiple disciplines (Page, 2007; Schwartz et al., 1993).

Worker Characteristics

Model constructs representing individual-level worker characteristics are chosen from workforce development literature, which is thoroughly reviewed in Chapter II, and include educational background (i.e., highest degree held), level of formal training in the worker's discipline and years of job experience (Boulton et al., 2011; Beck & Boulton, 2012; Hilliard & Boulton, 2012; Kennedy & Moore, 2001). These constructs are hypothesized to positively impact worker competence, which is defined as "personality characteristics associated with superior performance and high motivation" (Le Diest & Winterton, 2005; p.31) and often measured in public health organizations by assessing workers on a series of standardized competencies.

The worker characteristics of focus in this dissertation represent variables measured in accessible data sets. Literature points to other characteristics of individual workers that may be associated with worker competence and/or capacity; however, data do not yet exist to include these measures in the models used in my dissertation studies. These include: demographics; motivation to achieve goals and objectives; and attitudes, beliefs and perceptions toward the mission, climate and culture of the organization (Dato, Potter, Fertman, & Pistella, 2002; Woodard, 2004; Hilliard & Boulton, 2012). Future research should consider the collection and analysis of such data.

A reciprocal relationship is posited to exist between the concepts of organizational and worker characteristics. For example, organizational characteristics such as the extent to which training opportunities are offered, could affect the competence of the workers employed in that organization. Similarly, the educational background and experience of workers impacts the composition of the organization's workforce, potentially influencing how the organization chooses to structure its departments and programs. A reciprocal relationship is also noted between worker competence and capacity at the workforce and organizational levels, as it is possible that the constructs could have predictive qualities for each other. Organizational capacity is included as a predictor of competence in Chapter III; competence is not directly measured as a predictor of capacity in this dissertation, but is inferred as a predictor in Chapter IV through inclusion of variables that have predictive associations with it.

Organizational and worker characteristics are both shown in the model to have independent direct effects on capacity. Presumably, organizational characteristics would most likely affect organizational capacity and workforce characteristics would primarily affect workforce capacity; however, it is also possible that these multilevel characteristics would impact both levels of capacity and that workforce and organizational capacity may embody a reciprocal relationship itself.

Dissertation Overview

In following the pathways of the conceptual model, the dissertation starts with a thorough review of the literature, which leads to an analysis of state health department epidemiologist data to identify individual-level correlates of worker competence, and closes with an analysis of organizational workforce development policies and workforce characteristics to determine strength of association with two distinct measures of organizational capacity. My first paper, entitled "Systematic Review of Public Health Workforce Literature", synthesizes studies focused on four workforce research themes: workforce size and composition; workforce effectiveness and impact on population health; forecasting workforce demand; and workforce development policies. The systematic review included 157 articles published in the U.S. peer-reviewed and gray literature between 1985 and March 2012 and were identified by searching PubMed, ERIC, and Web of Science databases, Google search engine, and websites of national professional associations commonly cited in the peer-reviewed literature as having contributed to workforce research. Reference lists of seminal public health workforce articles were used to cross-check literature review results. Overall, results of the systematic review yielded few evidence-based findings, as a paucity of quantitative studies exist in the peer-reviewed literature. Despite the scarcity of workforce research, findings of the systematic review were valuable in identifying key workforce variables used in the dissertation analyses detailed in Chapters III and IV, including workforce size, competence, training and education background, and job experience.

In my second paper, titled "Assessing Multilevel Predictors of Worker Competence for State Health Department Epidemiologists", factors at the organizational and individual levels were analyzed to identify significant associations with self-assessed worker competence using a standardized set of Applied Epidemiology Competencies (CDC/CSTE, 2008). I used data collected in 2009 by the Council of State and Territorial Epidemiologists, which included competency scores reported by epidemiologists working in state health departments and variables that describe characteristics of the workers and the health departments in which they work. The study was guided by the following research questions: 1) what individual-level characteristics of workers significantly predict self-assessed competence; 2) what organizational-level characteristics of health departments predict average worker competency scores; and 3) do individual-level and organizational-level characteristics that predict worker competence vary by epidemiologist job tier? Study results showed that workforce characteristics that influence competence may vary depending on the job tier of the epidemiologist (i.e., entry-level, mid-level, or senior). Job experience was an important factor for all types of epidemiologists; educational background and formal training in epidemiology were also significant predictors of competence in several models; thus, these variables were included in the third dissertation paper.

My third paper, entitled "Measuring Capacity: An Assessment of Public Health, Environmental, and Agricultural Laboratory Capacity and its Association with Workforce Characteristics", examines two different measures of laboratory capacity and identifies workforce and other organizational factors significantly associated with those measures. I used data collected from directors of public health, environmental and agricultural laboratories (PHEAL) in 2011 by the Association of Public Health Laboratories and University of Michigan Center of Excellence in Public Health Workforce Studies, as this data set currently provides the most comprehensive workforce information for any public health discipline. PHEALs are an essential component of the public health system. They are typically located administratively within a local, state, or federal health department or other governmental agency. PHEALs have a common set of tasks and functions, although the scope of their duties may vary depending on the size of the laboratory. Their staff are similarly trained to carry out laboratory services, and they employ a similar set of job classifications and requirements.

As noted previously, organizational capacity is a concept of critical interest in PHSSR, yet the term is ill-defined and lacks standardized measures. In the third paper, I analyzed a model using a summary measure of PHEAL capacity as the outcome of interest and compared the results against a model using a composite averaged score of 19 laboratory program areas as the dependent variable to determine whether the measures produce significantly different result and whether one measure has stronger associations with workforce factors than the other. Workforce factors at the organizational level, including size of workforce, proportion of college-educated workers, and proportion of scientists in the workforce were included in both models. Workforce factors significantly associated with laboratory capacity included the size of the workforce and proportion of college-educated workers, although findings were mixed in terms of whether the association was positive or negative. PHEALs that provided several types of professional development and continuing education opportunities were also associated with higher laboratory capacity.

Chapter I Literature Cited

Beck, A.J., & Boulton, M.L. (2012). Building an effective workforce: a systematic review of public health workforce literature. *American Journal of Preventive Medicine*, *42,* S6-S16.

Beck, A.J., Boulton, M.L., Lemmings, J., & Clayton, J.L. (2012). Challenges to recruitment and retention of the state health department epidemiology workforce. *American Journal of Preventive Medicine, 42,* 76-80.

Benson, C.S. (1978). *The economics of public education* (3rd ed.). Boston: Houghton Mifflin.

Boulton, M.L., Hadler, J., Beck, A.J., Ferland, L., & Lichtveld, M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Reports, 126,* 84-93.

Butterfoss, F.D., Kegler, M.C., & Francisco, V.T. (2008). Mobilizing organizations for health promotion: Theories of organizational change. In Glanz K., Rimer B.K., & Viswanath, K. (Eds.), *Health behavior and health education: Theory, research and practice, 4th Ed.* (pp. 341-345). San Francisco: Jossey-Bass.

Centers for Disease Control and Prevention/Council of State and Territorial Epidemiologists. (2008). *Competencies for applied epidemiologists in governmental public health agencies (AECs).* Retrieved from: http://www.cdc.gov/appliedepicompetencies/.

Cioffi, J.P., Lichtveld, M.Y., & Tilson, H. (2004). A research agenda for public health workforce development. *Journal of Public Health Management and Practice, 10,* 186-192.

Consortium from Altarum Institute, the Centers for Disease Control and Prevention, the Robert Wood Johnson Foundation, and the National Coordinating Center for Public Health Services and Systems Research. (2012). A national research agenda for public health services and systems. *American Journal of Preventive Medicine, 42,* S72-S78.

Dato, V.M., Potter, M.A., Fertman, C.I., & Pistella, C.L. (2002). A capacity mapping approach to public health training resources. *Public Health Reports, 117,* 20-27.

Eisinger, P. (2002). Organizational capacity and organizational effectiveness among street level food assistance programs. *Nonprofit and Voluntary Sector Quarterly, 31,* 115-130.

Gebbie, K., Merrill, J., Hwang, I., Gebbie, E.N., & Gupta, M. (2003). The public health workforce in the year 2000. *Journal of Public Health Management and Practice, 9,* 79-86.

Health Resources and Services Administration. (2000). *The public health workforce: Enumeration 2000*. Washington, DC: US Department of Health and Human Services.

Hilliard, T.M., & Boulton, M.L. (2012). Public health workforce research in review: a 25-year retrospective. *American Journal of Preventive Medicine, 42,* S17-S28.

Institute of Medicine. (2003). *Who will keep the public healthy? Educating public health professionals in the 21st century.* Washington DC: National Academy Press.

Kennedy, V.C., & Moore, F.I. (2001). A systems approach to public health workforce development. *Journal of Public Health Management and Practice, 7,* 17-22.

Le Deist, F.D., Winterton, J. (2005). What is competence? *Human Resource Development International, 8,* 27-46.

Mays, G.P., Halverson, P.K., & Scutchfield, F.D. (2003). Behind the curve? What we know and need to learn from public health systems research. *Journal of Public Health Management and Practice, 9,* 179-82.

Mincer, J. (1974). *Schooling, experience, and earnings.* New York: Columbia University Press.

Novick, L.F., Morrow, C.B., & Mays, G.P. (Eds.) (2008). *Public health administration: Principles for population-based management* (2nd ed.). Sudbury, MA: Jones and Bartlett.

Page, S. (2007). Diversity and Problem Solving. *In the difference: How the power of diversity creates better groups, firms, schools, and societies*, 162-174. New Jersey: Princeton University Press.

Schultz, T.W. (1971). *Investment in human capital: The role of education and research.* New York: The Free Press.

Schwartz, R., Smith, C., Speers, M.A., Dusenbury, L.J., Bright, F., Hedlund, S., …Schmid, T.L. (1993). Capacity building and resource needs of state health agencies to implement community-based cardiovascular disease programs. *Journal of Public Health Policy, 14,* 480-493. Retrieved from: http://www.jstor.org/stable/3342879.

Scutchfield, F.D. & Patrick, K. (2007). Public health systems research. The new kid on the block. *American Journal of Preventive Medicine, 32,* 173-174.

Steckler, A., Goodman, R.M., & Kegler, M.C. (2002). Mobilizing organizations for health enhancement: Theories of organizational change. In Glanz K., Rimer B.K., & Lewis F.M. (Eds.), *Health behavior and health education: Theory, research and practice* (pp. 335-357). San Francisco: Jossey-Bass.

Sweetland, S.R. (1996). Human capital theory: Foundations of a field of inquiry. *Review of Educational Research, 66,* 341-359.

Tilson, H. & Gebbie, K.M. (2004). The public health workforce. *Annual Review of Public Health*, *25,* 341-356.

Woodard, G.B. (2004). *Health promotion capacity checklists: A workbook for individual, organizational and environmental assessment*. Saskatchewan, Canada: Prairie Region Health Promotion Research Centre. Retrieved from: http://www.prhprc.usask.ca/publications/finalworkbook.pdf.

University of Michigan Center of Excellence in Public Health Workforce Studies/Association of Public Health Laboratories. (2012). *2011 national laboratory capacity assessment.* Ann Arbor, MI: University of Michigan.

University of Michigan/Center of Excellence in Public Health Workforce Studies, University of Kentucky/Center of Excellence in Public Health Workforce Research and Policy. (2012). *Strategies for enumerating the U.S. government public health workforce.* Atlanta, GA: US Department of Health and Human Resources, Centers for Disease Control and Prevention.

CHAPTER II

Systematic Review of Public Health Workforce Literature

Background

The public health workforce literature has grown substantially in the last 25 years alongside increasing interest in understanding the size and composition, training, recruitment, and retention of the public health workforce. However, no systematic assessment of the scientific merit of the workforce literature has been published previously. Systematic reviews are useful for identifying, selecting, and critically appraising literature that relates to specific research questions (Wiesler & McGauran, 2010). Findings of systematic reviews can help inform research agendas for public health systems and services research (PHSSR) by delineating the gaps in empirical studies of the public health workforce (Scutchfield, Perez, Monroe & Howard, 2012).

This review defines the "public health workforce" as those persons providing Essential Public Health Services (EPHS), regardless of the nature of the employing agency (US DHHS, 1997). EPHS refers to the 10 public health activities that should be undertaken in all communities, according to the Core Public Health Functions Steering Committee (CDC, 2010). These include:

1. Monitor health status to identify and solve community health problems.
2. Diagnose and investigate health problems and health hazards in the community.
3. Inform, educate and empower people about health issues.
4. Mobilize community partnerships and action to identify and solve health problems.

5. Develop policies and plans that support individual and community health efforts.
6. Enforce laws and regulations that protect health and ensure safety.
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable.
8. Assure competent public and personal health care workforce.
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.
10. Research for new insights and innovative solutions to health problems.

This definition encompasses workers in governmental public health organizations, other governmental organizations that provide public health services, non-governmental and community-based organizations, and private or for-profit organizations, among others. Although a broad definition is being adopted for this paper in order to include as much literature on the public health workforce as possible, workers in governmental public health organizations are considered “core” public health workers (UM/UK, 2012) and are the focus of the predominance of the articles reviewed.

I present a summary of public health workforce articles published from 1985-2012 that contributed to the development of a public health workforce research agenda, and systematically review literature addressing research questions based on previously published public health workforce research themes: (Crawford et al., 2009)

1. What is the size and composition of the workforce?
2. How can the workforce's effectiveness and impact on population health be measured?
3. How can the workforce be monitored and demand projected?
4. What policy measures affect public health workforce development?

Methods

The study was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) (Moher, Liberati, Tetzlaff,

& Altman, 2009). A 27-item PRISMA checklist was developed in 2005 to improve consistency in how systematic reviews and meta-analyses are conducted and reported. Although initially adopted for randomized trials, PRISMA can be used for other types of research (Moher et al., 2009). The checklist includes guidelines for what elements should be included in the title, abstract, introduction, methods, results, discussion, and funding acknowledgement sections of systematic review papers.

Eligibility Criteria

Although the public health workforce is the primary focus of this systematic review, I included relevant health care workforce literature (i.e., the studies met the inclusion criteria) when public health studies were insufficient to address the research questions. The following criteria were used to determine reference eligibility for inclusion: 1) peer-reviewed articles are published in a U.S. journal; gray literature is published by a U.S. organization or government agency; 2) the main theme(s) of the article address public health workforce research or relate to at least one of the following workforce focus areas: size and composition; forecasting demand; effectiveness and health impact; and policy; and 3) the article focuses on the domestic workforce. A complete bibliographic list of reviewed references is provided in the chapter appendix.

Information Sources

Peer-reviewed articles were identified using PubMed, ERIC, and Web of Science databases. PubMed and Web of Science were chosen for use because of their overall breadth and inclusion of articles that span medical and social science literature; ERIC was utilized in this search process because of its potential to identify literature that pertains to education and training of the workforce and based on its frequent use in other public health workforce review studies (Crawford et al., 2009). Google search engine was used to identify gray literature. Additionally, I searched for non-peer reviewed technical reports on websites of national professional associations commonly cited in the peer-reviewed literature as having contributed to workforce research. Examples include the Association of State and Territorial Health Officials (ASTHO) and the National Association of County and City Health Officials (NACCHO), among others. Finally, I reviewed the references cited by articles that provided descriptive information about the public health workforce or reviewed public health workforce literature to cross-check the search results and identify relevant articles that may have been missed in the formal search of peer-reviewed and gray literature.

Search Strategy

January 1, 1985 was chosen as the start of the search time period in order to maximize the probability of capturing publications associated with the launch of major national initiatives aimed at improving public health infrastructure such as the Institute of Medicine's *Future of Public Health* report and related recommendations (IOM, 1988; CDC, 2001). Few public health workforce studies were published prior to 1985. I used the same search terms for all databases and search engines and filtered search results by country, automatically excluding international literature. Search terms were derived from thematic focus areas identified for each research question. "Public health workforce" was used as the first search term, and then in combination with the following terms and phrases: “development”, “enumeration,” “capacity,” “policy,” “infrastructure,” “performance measures,” and “composition.” Some search terms corresponded directly to one research theme, while others were broad and encompassed multiple themes. In order to frame the results in the context of the research questions, article summaries are presented by research theme as opposed to search term.

Results

Description of Studies

The initial search of “public health workforce” returned 20,031 results in PubMed, 620 in Web of Science, and 23 in ERIC. A scan of abstracts revealed that the majority of these articles were not specific to public health; several more were too general or didn’t address the research themes. I used the additional search terms outlined in the Methods section in combination with “public health workforce” to filter the results. Results ranged from 17-5966 articles in PubMed, 5-1649 articles in Web of Science, and 3-13 in ERIC (Table 2.1). After grouping article abstracts by theme and eliminating those that did not specifically focus on the public health workforce, 236 articles were initially chosen for review from the PubMed search; 135 were later excluded for lack of focus on any of the review’s workforce research themes, leaving a total of 101 articles that met the inclusion criteria. The Web of Science database yielded 72 potential articles to be included in the review, 59 of which were later excluded because they were duplicates of articles found in PubMed, leaving 13 articles used in the review. No unique articles were obtained from ERIC.

Technical reports, issue briefs, and annual reports were among the types of documents included as part of the gray literature analysis. The majority of gray literature relevant to this review is published by national professional associations/organizations, and governmental public health agencies and therefore is generally accessible on the organizations' websites. Google searches using all search terms yielded between 0 and 157,000 results. Forty-three documents were included in this review. Twenty-four documents were published by public health professional organizations; 15 were by governmental health agencies; and the remaining 4 were published by University academic centers focused on public health workforce studies.

A total of 157 articles met the inclusion criteria. Preliminary search results produced 308 peer-reviewed articles and 44 technical reports that were initially selected for inclusion. A comprehensive review of the selected literature resulted in the removal of 111 duplicate articles; an additional 35 records were excluded for being too general or focusing on the international workforce, and 49 more full-text articles were eliminated because they discussed workforce themes outside the scope of this review (Figure 2.1). One hundred-one articles (64%) used in the review were identified using PubMed; 44 (27%) gray literature documents were identified through Google; and Web of Science contributed 13 (8%) articles (Table 2.1). Few potential articles were identified in ERIC, none of which were chosen for inclusion.

The articles and documents selected for inclusion are divided among five focus areas. Thirty-seven (24%) of the articles are considered "cross-cutting" because they discuss aspects of several research themes or give context to the research themes by providing historical information and general insights about addressing public health workforce issues. Although these articles are not research-based, they are important to include in the systematic review because they help define important research questions and themes in the PHSSR workforce agenda. Workforce size and composition is addressed by 40 (25%) articles; 45 articles (29%) focus on assessing workforce effectiveness through capacity and performance measures and/or relating workforce and organizational performance to health impact; 23 articles (15%) discuss issues of workforce shortage and strategies for workforce management; and 12 articles (8%) provide policy suggestions for strengthening the public health workforce (Figure 2.2).

Summary of Results

A review of the 157 documents selected for inclusion found only one-quarter were based on research studies, with the rest being primarily articles broadly describing aspects of the public health workforce. Data analysis was limited to descriptive statistics for nearly all studies. Study findings by research theme follow.

Cross-Cutting Public Health Workforce Articles: Framing the Workforce Agenda.

The Institute of Medicine (IOM) published a seminal report in 1988, *The Future of Public Health,* which described the public health system as being in “disarray”, and urged better preparation of the public health workforce (IOM, 1988). In response, numerous public health practitioners, federal officials, and researchers published reports, editorials, and commentaries, most of which constituted general calls to action and/or provided suggestions to strengthen the public health system. All uniformly maintain that the workforce is the backbone of the public health infrastructure, critical to the success of public health programs, and requires immediate intervention to improve capacity to deliver essential public health services (CDC, 2001; Gebbie, Merrill, & Tilson, 2002; Lichtveld, Cioffi, Henderson, Sage, & Steele, 2003; Popovic, 2009; Tilson & Gebbie, 2004).

The inherent challenges in building an adequately-trained, adaptable public health workforce are emphasized in several articles (Lichtveld & Cioffi, 2003). Roper et al. stated in 1992 that, "as the scope of public health programs broadens and they become more complex, limitations in the capacity of the public health workforce to perform basic practices are apparent." By the end of the decade, a highly-trained workforce was deemed the "key" to public health infrastructure and a continuing education core curriculum for all public health professionals was suggested to enhance workforce development efforts and increase workforce competence (Gebbie, 1999).

In addition to proposing strategies for strengthening the public health workforce, several articles and technical reports focused on the development of public health workforce research frameworks (Lenaway et al., 2006; Moore, 2009; Popovic, 2009; Summerfelt, Tilson, & Crawford, 2009; Thacker, 2009). Proposed priority research areas include determining predictive relationships between performance indicators for workforce systems and health outcomes; identifying effective methods for building individual competency; determining best indicators for measuring workforce performance; establishing systems to track and monitor data about the workforce; and describing the components of the employment system in public health (Cioffi, Lichtveld & Tilson, 2004). These ideas were expounded upon in a 2009 *Journal of Public Health Management and Practice* supplement featuring articles from leading PHSSR researchers who highlighted eight public health workforce research themes and encouraged the development of more analytically focused, quantifiable models for assessing workforce demand (Crawford et al., 2009; Boulton, 2009).

Federal health agencies have also provided key input into developing strategies for assessing and strengthening the public health workforce. A 2005 report released by the Health Resources and Services Administration (HRSA) pointed out that despite the significant number of studies focused on the public health workforce, questions remain about workforce composition, availability, functions, and preparation to carry out duties because the workforce is difficult to define, found in many settings, and serves as a provider of a wide range of services, all of which make measurement difficult (HRSA, 2005). The report's key recommendations call for developing innovative workforce recruitment strategies; providing continuing education training and educational advancement opportunities for the current workforce; developing loan repayment programs for public health workers; developing a model public health curriculum; and monitoring size and composition of the public health workforce on a regular basis (HRSA, 2005).

Size and Composition of the Public Health Workforce.

Forty of the articles reviewed pertained to the first research question framing the systematic review, which focuses on the size and composition of the workforce. Systematic monitoring of the size and composition of the public health workforce is a research theme repeatedly emphasized by public health officials, policymakers and PHSSR researchers. The most recent effort to enumerate the U.S. public health workforce occurred in 2000, when an analysis of secondary data estimated close to

450,000 persons working in multiple occupational categories (Gebbie, Merrill, Hwang, Gebbie, & Gupta, 2003; HRSA, 2000). Although the authors noted limitations, the results provided the first comprehensive national enumeration of public health workers. Other enumeration studies performed at both the state and federal levels also often included information about workforce location, occupations, education, and areas of public health practice (Haughton & George, 2008; Turnock & Hutchison, 2000; Kennedy, Spears, Low, & Moore, 1999; Boulton, Lemmings & Beck, 2009; CDC, 2009; Lichtveld, Boulton, Lemmings, & Gale, 2009).

National professional organizations have actively monitored workforce characteristics in governmental public health settings for several years. ASTHO published 6 reports from 2005-2011 that provide strategies for enumerating the workforce and summarize the composition of various sectors of the public health workforce (ASTHO, 2004; ASTHO, 2005; ASTHO, 2006; ASTHO, 2007; ASTHO, 2007; ASTHO, 2011). The 2010 ASTHO study estimated 103,280 workers in state and territorial health departments (ASTHO, 2011). Similarly, the National Association of County and City Health Officials released profile data of local health departments, including summaries of the size and composition of the national local public health workforce (NACCHO 2005; NACCHO, 2008; NACCHO, 2011). NACCHO reported approximately 160,000 workers in local health departments in 2010 (NACCHO, 2011).

Finally, a few organizations have taken the lead in estimating the number of workers in sub-disciplines of public health, though few of these studies are found in the peer-reviewed literature, with the notable exception of epidemiology and public health nutrition workforce studies (Haughton & George, 2008; Boulton et al., 2009; Boulton, Hadler, Beck, Ferland & Lichtveld, 2011). The 2,193 state health department epidemiologists reported by the Council of State and Territorial Epidemiologists in 2009 (CSTE, 2009) was similar to the 2,500 estimated by ASTHO. The enumeration of public health nutritionists in 2007 by the Association of State and Territorial Public Health Nutrition Directors found 2,891 and 4,477 nutritionists in state and local health departments, respectively (Haughton & George, 2008), compared to 1,557 and 4,600 nutritionists enumerated in 2010 by ASTHO and NACCHO, respectively. Different study time periods and varying study methods likely account for the discrepancy in findings.

As researchers continue to consider the importance of public health workforce surveillance, in-depth studies reviewing the strengths and limitations of workforce data sources, such as data collected by the Bureau of Labor Statistics, Office of Personnel Management, and the national professional groups previously mentioned, have been conducted (UM/UK, 2012). Findings of these studies confirm that no data source or combination of data sources can adequately enumerate and monitor the public health workforce, and critical issues such as varying definitions of public health workforce classifications and data collection methodology must be addressed (UM/UK, 2012; Sumaya, 2012). A comprehensive classification database system for the public health workforce would enable researchers to conduct more studies to predict the effect of workforce factors on organizational performance and health outcomes, forecast public health workforce shortages, and provide policymakers with better recommendations to enhance workforce development.

Workforce Effectiveness and Health Impact.

The scope of the systematic review was broadened slightly to include 45 articles that inform, rather than answer, the research question related to workforce effectiveness and impact on population health. PHSSR researchers have repeatedly underscored the importance of conducting empirical research studies to determine whether associations exist between workforce characteristics, effectiveness, and population health outcomes (Summerfelt et al., 2009; Thacker, 2009; Cioffi et al., 2004; Boulton, 2009). However, this review found no such studies existed in the public health literature. Instead, I include public health studies focused on organizational capacity and performance measurement, both of which would likely be considered intermediaries in any relationship between workforce effectiveness and health outcomes. In addition, I include articles from the healthcare literature that provide models for assessing organizational and workforce capacity that may be applied to public health.

Turnock and colleagues introduced the concept of organizational capacity and performance measurement in public health in 1995 when he surveyed local health departments to assess change in ability of the organization to carry out public health functions effectively (Turnock, Handler, Hall, Lenihan, & Vaughan, 1995). Their study emphasized the role of strong leadership and sufficient availability of staff as key factors influencing positive performance. Subsequently, CSTE assessed epidemiology capacity and workforce characteristics in all state and territorial health departments four times since 2001 by surveying State Epidemiologists on current and needed workforce levels, as well as capacity in 8 program areas to perform essential public health services (Boulton et al., 2009; Boulton et al., 2011; CSTE, 2004; CSTE, 2008; CSTE, 2009).

Although the studies failed to uncover significant correlations between workforce factors and epidemiology capacity, associations between states' population and the number of epidemiologists employed at state health departments ($p<.0001$) and agencies' organizational structuring of epidemiologists and number of epidemiologists ($p=.011$) were found (Boulton et al., 2009).

Overall, the public health workforce literature makes a strong argument for conducting research that can better measure performance of public health agencies and document the outcomes of public health practice to assist health departments with quality improvement efforts and help highlight successes for policymakers (Turnock & Handler, 1997). The workforce is a vital component of the structural capacity of a public health agency and, therefore, must be considered in measures of organizational performance (Handler, Issel, & Turnock, 2001). Notably, a 2010 article highlights the first study to attempt correlation of local health department resources with changes in state-level health outcomes. Results showed that increases in local health department expenditures were significantly associated with decreases in infectious disease morbidity at the state level ($p=.037$) and increases in staffing were significantly associated with decreases in cardiovascular disease mortality ($p=.014$) using multivariate regression. However, health department factors were not significantly associated with other health outcomes, such as smoking prevalence, obesity prevalence, infant mortality, cancer deaths, or years of potential life lost (Erwin, Greene, Mays, Ricketts, & Davis, 2011).

Forecasting Public Health Workforce Demand.

Studies that use measures to forecast public health workforce demand are scarce in the literature requiring supplementation by relevant articles in the healthcare literature.

Twenty-three review articles addressed the research question of how the workforce could be monitored and demand projected. Several reports have been released forecasting a shortage of public health workers, though specific details related to worker discipline, training level, and functional ability are not generally known and quantitative methods for predicting workforce shortage in the public health system have not been established (ASPH, 2008; CSG, 2004; Draper, Hurley, & Lauer, 2008; Gebbie & Turnock, 2006). Few studies have looked at staffing models for specific public health activities, such as mass vaccination clinics, as a way to estimate the number of workers needed (Porter et al., 2011). Authors who foresee a "workforce crisis" in public health emphasize the use of recruitment and retention strategies to avoid potential negative impact on the public health system and population health (CSG, 2004; Draper, Hurley, & Lauer, 2008; Gebbie & Turnock, 2006; Beck & Boulton, 2012). Challenges to sustaining the workforce include the reduction of federal bioterrorism funds, which have supported thousands of new public health workers including epidemiologists, laboratorians, and preparedness personnel over the past decade, and the expected departure of up to 25% of retirement-eligible governmental public health workers within the next few years (ASPH, 2008; Gebbie & Turnock, 2006; Beck, Boulton, Lemmings & Clayton, 2012).

The healthcare workforce literature features quantitative methods for estimating workforce demand. For example, a model developed to predict needed nursing staff levels based on various hospital conditions relies on a mathematical formula using nurse-patient ratios, bed utilization, number of admissions, and admission days as formula inputs (Elkhuizen, 2007). Similarly, an analytic framework for determining desired characteristics of the healthcare workforce uses variables relating to health needs and provider productivity (Birch, Kephart, Murphy, O'Brien-Pallas, Alder, & MacKenzie, 2009). Finally, Buerhaus suggests economic factors that may help predict demand and employment turnover among nurses, including staff attitude toward job, job satisfaction, and spouse's employment status (Buerhaus, 2009). These articles provide support for developing analytic measures of workforce capacity that can be applied to public health to ensure workforce demand is understood and addressed.

Public Health Workforce Policy.

Only 12 systematic review articles were thematically related to the final research question asking what policy measures affect public health workforce development. Although development and implementation of policy initiatives to strengthen the public health workforce are supported throughout the literature, none of the 12 articles were empirical studies on workforce policy. A 2002 article cited the need for a strong public health infrastructure to protect community health and outlined possible policies for implementation, many of which focused on assessment of workforce composition and competency, including further development of an array of workforce development programs funded by the Centers for Disease Control and Prevention (Baker & Koplan, 2002). Other researchers have noted the need to address the IOM's extensive policy recommendations for strengthening the public health infrastructure, including the workforce (Tilson & Berkowitz, 2006).

A 2001 report published by HRSA as a companion piece to *Healthy People 2010* promoted several workforce development policy initiatives to strengthen the public health workforce such as increasing the number of under-represented minorities entering health professions programs; increasing the number of public health agencies offering continuing education courses; and increasing the number of public health agencies building personnel and training systems around competencies in the essential public health services (HRSA, 2001). These policies served as the foundation for developing and administering workforce development grant programs supported by HRSA.

Discussion

Summary of Evidence

The 157 articles in this systematic review included few that provide any evidence-based findings, as the preponderance of articles in the systematic review are principally descriptive or suppositional in nature. Although the public health literature contains numerous and repeated calls to action about the importance of conducting empirical research to address critical public health workforce issues, it has largely failed to produce the quantitative evidence needed to scientifically buttress the many recommendations related to workforce development, effectiveness, and policy called for by public health leaders and researchers. These weaknesses are all the more glaring compared with the healthcare workforce literature and speak to the significant need for public health researchers to actively assess the utility of quantitative methods drawn from other fields for monitoring workforce size and composition, shortage and demand, and associations with health outcomes.

When comparing the availability of empirical workforce research in the healthcare literature to the public health literature, it is important to point out that healthcare workforce research benefits from more federal funding support (US DHHS, 2009), systematic federal monitoring of much of the health professions workforce (HRSA, 2011), precise and measurable clinical outcomes focused at the individual level, rather than population level, and the availability of workforce certification and licensure data. In addition, compared to the public health workforce, the healthcare workforce is more clearly defined and generally uses narrower job classifications. While the breadth and diversity of the public health workforce greatly contributes to the effective delivery of public health services, it also presents a significant challenge for public health researchers in the design of empirical studies.

The review articles elucidated multiple strategies for enumerating, assessing capacity, developing policy, and determining demand for the public health workforce, although no methodological "gold standard" is identified. Approximately 45% (51/114) of the peer-reviewed publications in this review were found in the same journal. This could be perceived as a potential weakness both because of the overconcentration in a single journal but also because the journal may not reach a wider audience, which could help promote, highlight, and generate dialogue about PHSSR amongst researchers. In addition, almost one-third of all references cited in the publications reviewed are drawn from non-peer-reviewed technical reports, some of which were included in this review. Again, this speaks to the general paucity of public health workforce research literature and the pressing need to encourage new researchers with novel ideas to publish in the peer-reviewed literature in a wide variety of public health journals to reach as broad a readership as possible.

The workforce literature could also be bolstered through more frequent use of theory as a foundation for developing quantitative models and designing research for published studies. Organizational Development Theory and Interorganizational Relations

Theory are examples of theories that consider organizational factors, including workforce factors, and their impact on organizational effectiveness and how organizations work together, which could be useful when considering measures of organizational and workforce capacity (Steckler, Goodman & Kegler, 2002). Fewer than 5 of the 157 publications reviewed mentioned any type of theory either as a basis for developing a study or as a recommendation for the research agenda. Organizational and systems theories should be incorporated to guide development of conceptual models and frameworks for measuring capacity, something which has been mostly overlooked in the literature thus far. Finally, very few articles in this systematic review cited workforce or capacity studies in medicine or nursing despite remarkable progress in those fields. Public health could potentially benefit from a more interdisciplinary approach by consulting with experts in other health fields, as well as business, economics and other nontraditional collaborators, to gain greater insight into measurement of public health workforce capacity.

Despite the limitations, the current body of literature provides an important foundation for beginning to answer the many questions related to our national public health workforce. Of note, the majority of this literature is less than ten years old and only recently has PHSSR gained greater credibility as an important area of research inquiry as measured by increases in funding support. Thus far, the lack of a sustained funding stream in this area has contributed to a negative feedback loop between too little research and too little funding support. A study characterizing the community of researchers involved in PHSSR found that although there is a core group of researchers who participate in PHSSR, most publish on other research topics, which could support the idea that PHSSR is still an emerging field that cannot yet support a singular focus (Bales et al., 2011). However, the recent increases in available funding should help improve the intellectual currency of PHSSR in academia making it a more attractive area for junior researchers while also enhancing the recognition of PHSSR as a viable area of inquiry, and serving faculty as a respected and acceptable research concentration in their pursuit of promotion and tenure. Until PHSSR generally, and workforce research specifically, adequately addresses these concerns, the field will likely persist in attracting relatively few researchers and the literature will continue to languish.

Limitations of Systematic Review

There are several limitations to the methods used for this systematic review. First, the numerous results obtained in PubMed were not easily filtered; it is possible that relevant literature was unintentionally excluded. The use of additional MeSH terms or Boolean operators may have yielded additional or different results. However, by cross-checking the results with reference lists of highly cited public health workforce articles, I believe the number of relevant articles excluded from the review is minimal.

Second, in some cases literature with more healthcare relevance was included in the review for the research themes. These articles were obtained using public health search terms, despite being less specific to public health. They are included because of their value in developing strategies to measure public health workforce capacity and forecast workforce demand.

Finally, the scope of this review was limited to four main research focus areas. Public health workforce articles tend to address several workforce development and infrastructure concerns, including worker training, recruitment, and workforce diversity. These focus areas were outside the scope of the research questions; however, excluding articles that highlight these areas would have resulted in a substantial decrease in articles used for this review. Therefore, it is likely that articles cited in this systematic review may have been used in other public health workforce reviews (Hilliard & Boulton, 2012). Additionally, several articles addressed more than one research theme and could have been categorized differently.

Conclusions

A critical analysis of the literature from this systematic review of public health workforce research was largely insufficient to definitively answer the attendant research questions. Although policymakers, practitioners, and public health leaders alike, many of whom were authors of articles in this review, have continued to stress the importance of monitoring the size and composition of the public health workforce, surprisingly little progress has been made in that regard over the last decade since the last national public health workforce enumeration. The challenges to advancing research in this area will require the successful resolution of financial and organizational barriers to the implementation of a workforce surveillance system, including development of a standard taxonomy for public health workforce job classifications. Establishing a system for monitoring the public health workforce may be the most critical step in promoting a research agenda given the importance of a timely supply of workforce data to the accurate characterization of future workforce shortages, understanding capacity and effectiveness, and informing policy initiatives.

The few quantitative public health workforce studies that have been completed to date are an encouraging start. The finding of an association between staffing level and health outcomes (Erwin et al., 2011) points to the need to further explore capacity models that consider workforce inputs, organizational processes, delivery of public health services, and the resulting population health outcomes. Linear relationships between population size and epidemiologist workforce size suggest that the development of a workforce ratio may help public health officials in determining ideal staffing levels and monitor workforce demand (Boulton et al., 2009).

The key findings of this review suggest that programs that support additional empirical research studies on public health workforce should be a priority in health systems reform. Without quantifiable measures of public health functions that can be used to gauge workforce supply and demand, combined with consistent data on workforce size and composition, it will be difficult to develop an accurate assessment of workforce effectiveness and its impact on population health. Systematic collection of workforce data would help researchers undertake empirical studies on a more consistent basis. The Patient Protection and Affordable Care Act (PPACA), signed into law March 2010, includes provisions to increase the public health workforce and strengthen quality measurement (CRS, 2010). Loan repayment programs, workforce grants for state and local programs, public health fellowships, preventive medicine training grants, and reauthorization of public health workforce programs are all initiatives proposed by the PPACA. Given the emphasis on quality measurement, it would be ideal for PPACA funding recipients to be required to systematically collect and report data on workers recruited, trained, and supported with federal dollars. Reporting mandates are common requirements for grants; a coordinated effort for collecting data that could provide measurable inputs for workforce capacity models, as well as quantifiable outputs could benefit PHSSR studies substantially.

Chapter II Literature Cited

Association of Schools of Public Health. (2008). *Policy brief: Confronting the public health workforce crisis*. Washington, DC: ASPH.

Association of State and Territorial Health Officials. (2004). *State public health employee worker shortage report: A civil service recruitment and retention crisis.* Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2005). *Strategies for enumerating the public health workforce.* Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2006). *Issue brief: Public health workforce challenges: Public health epidemiologists*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2007). *2007 state public health workforce survey results*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2007). *State public health workforce brief: 2007 workforce trends profile*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2011). *2010 profile of state public health*. Washington, DC: ASTHO.

Baker, E.L., & Koplan, J.P. (2002). Strengthening the nation's public health infrastructure: historic challenge, unprecedented opportunity. *Health Affairs, 21,* 15-27.

Bales, M.E., Johnson, S.B., Keeling, J.W., Carley, K.M., Kunkel, F., & Merrill, J.A. (2011). Evolution of coauthorship in public health services and systems research. *American Journal of Preventive Medicine, 41,* 112-117.

Beck, A.J., Boulton, M.L., Lemmings, J., & Clayton, J.L. (2012). Challenges to recruitment and retention of the state health department epidemiology workforce. *American Journal of Preventive Medicine, 42,* 76-80.

Birch, S., Kephart, G., Murphy, G.T., O'Brien-Pallas, L., Alder, R., & MacKenzie, A. (2009). Health human resources planning and the production of health: development of an extended analytical framework for needs-based health human resources planning. *Journal of Public Health Management and Practice, 15,* S56-S61.

Boulton, M.L. (2009). Toward a more analytic framework for public health workforce research. *Journal of Public Health Management and Practice, 15,* S62-S63.

Boulton, M.L., Lemmings, J., & Beck, A.J. (2009). Assessment of epidemiology capacity in state health departments, 2001-2006. *Journal of Public Health Management and Practice, 15,* 328-336.

Boulton, M.L., Hadler, J., Beck, A.J., Ferland, L., & Lichtveld, M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Reports, 126,* 84-93.

Buerhaus, P.I. (2009). The shape of recovery: economic implications for the nursing workforce. *Nursing Economics, 27,* 338-340, 336.

Centers for Disease Control and Prevention. (2001). *Public health's infrastructure: a status report.* Atlanta, GA: CDC.

Centers for Disease Control and Prevention. (2009). Assessment of epidemiology capacity in state health departments- United States. *MMWR Morbidity and Mortality Weekly Reports, 58,* 1373-1377.

Centers for Disease Control and Prevention. (2010). *National public health performance standards: 10 essential public health services.* Retrieved from: http://www.cdc.gov/nphpsp/essentialservices.html.
Cioffi, J.P., Lichtveld, M.Y., & Tilson, H. (2004). A research agenda for public health workforce development. *Journal of Public Health Management and Practice, 10,* 186-192.
Congressional Research Service. (2010). *Public health, workforce, quality, and related provisions in the Patient Protection and Affordable Care Act*. Washington, DC: CRS.
Council of State Governments. (2002). *Public health worker shortages.* Lexington, KY: Council of State Governments.
Council of State and Territorial Epidemiologists. (2004). *2004 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.
Council of State and Territorial Epidemiologists. (2006). *2006 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.
Council of State and Territorial Epidemiologists. (2010). *2009 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.
Crawford, C.A.G., Summerfelt, W.T., Roy, K., Chen, Z., Meltzer, D.O., & Thacker, S.B. (2009). Perspectives on public health workforce research. *Journal of Public Health Management and Practice, 15,* S5-S15.
Draper, D.A., Hurley, R.E., & Lauer, J.R. (2008). Public health workforce shortages imperil nation's health. *HSC Research Brief, April,* 1–8.
Elkhuizen, S.G., Bor, G., Smeenk, M., Klazinga, N.S., & Bakker, P.J.M. (2007). Capacity management of nursing staff as a vehicle for organizational improvement. *BMC Health Services Research, 7,* 196.
Erwin, P.C., Greene, S.B., Mays, G.P., Ricketts, T.C., & Davis, M.V. (2011). The association of changes in local health department resources with changes in state-level health outcomes. *American Journal of Public Health, 101,* 609-615.
Gebbie, K.M. (1999). The public health workforce: key to public health infrastructure. *American Journal of Public Health, 89,* 660-661.
Gebbie, K.M., Merrill, J., & Tilson, H.H. (2002). The public health workforce. *Health Affairs, 21,* 57-67.
Gebbie, K., Merrill, J., Hwang, I., Gebbie, E.N., & Gupta, M. (2003). The public health workforce in the year 2000. *Journal of Public Health Management and Practice, 9,* 79-86.
Gebbie, K.M., & Turnock, B.J. (2006). The public health workforce 2006: new challenges. *Health Affairs, 25,* 923–932.
Handler, A., Issel, M., & Turnock, B. (2001). A conceptual framework to measure performance of the public health system. *American Journal of Public Health, 91,* 1235-1239.
Haughton, B. & George, A. (2008). The public health nutrition workforce and its future challenges: The US experience. *Public Health Nutrition, 11,* 782-91.
Health Resources and Services Administration. (2000). *The public health workforce: Enumeration 2000*. Washington, DC: US Department of Health and Human Services.
Health Resources and Services Administration. (2001). *The key ingredient of the national prevention agenda: Workforce development*. Washington, DC: US Department of Health and Human Services.

Health Resources and Services Administration. (2005). *Public health workforce*. Washington, DC: US Department of Health and Human Services.

Health Resources and Services Administration. (2011). *National Center for Health Workforce Analysis*. Retrieved 15 Nov 2011 from: http://bhpr.hrsa.gov/healthworkforce/index.html.

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

Kennedy, V.C., Spears, W.D., Loe, H.D., & Moore, F.L. (1999). Public health workforce information: a state-level study *Journal of Public Health Management and Practice, 5,* 10-19.

Lenaway, D., Halverson, P., Sotnikov, S., Tilson, H., Corso, L., & Millington, W. (2006). Public health systems research: setting a national agenda. *American Journal of Public Health, 96,* 410-413.

Lichtveld, M.Y. & Cioffi, J.P. (2003). Public health workforce development: progress, challenges, and opportunities. *Journal of Public Health Management and Practice, 9,* 443-50.

Lichtveld, M.Y., Cioffi, J., Henderson, J., Sage, M., & Steele, L. (2003). Editorial. People protected – public health prepared through a competent workforce. *Journal of Public Health Management and Practice, 9,* 340-343.

Lichtveld, M.Y., Boulton, M.L., Lemmings, J., & Gale, J. (2008). From competencies to capacity: assessing the national epidemiology workforce. *Public Health Reports*, *123,* 128-135.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA statement. *PLoS Medicine, 6,* 1-6.

Moore, J. Studying an ill-defined workforce: public health workforce research. (2009). *Journal of Public Health Management and Practice, 15,* S48-S53.

National Association of County and City Health Officials. (2005). *2005 national profile of local health departments.* Washington DC: NACCHO.

National Association of County and City Health Officials. (2008). *2008 national profile of local health departments.* Washington DC: NACCHO.

National Association of County and City Health Officials. (2011). *2010 national profile of local health departments.* Washington, DC: NACCHO.

Popovic, T. (2009). Workforce science: a critical component to ensuring future of health. *Journal of Public Health Management and Practice, 15,* S3-S4.

Porter, D., Hall, M., Hartl, B., Raevsky, C., Peacock, R., Kraker, D., Walls, S., & Brink, G. (2011). Local health department 2009 H1N1 influenza vaccination clinics- CDC staffing model comparison and other best practices. *Journal of Public Health Management and Practice, 17,* 530-533.

Roper, W.L., Baker, E.L., Dyal, W.W., & Nicola, R.M. (1992). Strengthening the public health system *Public Health Reports, 107,* 609-15.

Scutchfield, F.D., Perez, D.J., Monroe, J.A., & Howard, A.F. (2012). New public health services and systems research agenda: directions for the next decade. *American Journal of Preventive Medicine, 42,* S1-S5.

Steckler, A., Goodman, R.M., & Kegler, M.C. Mobilizing organizations for health enhancement. In: Glanz, K., Rimer, B.K., Lewis, F.M., eds. (2002). *Health behavior*

and health education: Theory, research and practice. 3rd ed (pp. 335-360). San Francisco, CA: Jossey-Bass.
Sumaya, C.V. (2012). Enumeration and composition of the public health workforce: challenges and strategies. *American Journal of Public Health, 102,* 469-474.
Summerfelt, W.T., Tilson, H.H., & Crawford, C.A.G. (2009). Moving forward with workforce development research in public health *Journal of Public Health Management and Practice, 15,* S1-S2.
Thacker, S.B. (2009). Guide for applied public health workforce research: an evidence-based approach to workforce development. *Journal of Public Health Management and Practice, 15,* S109-S112.
Tilson, H. & Gebbie, K.M. (2004). The public health workforce. *Annual Review of Public Health*, *25,* 341-356.
Tilson, H. & Berkowitz, B. (2006). The public health enterprise: examining our twenty-first-century policy challenges. *Health Affairs, 25,* 900-910.
Turnock, B.J., Handler, A., Hall, W., Lenihan, P., & Vaughn, E. (1995). Capacity-building influences on Illinois local health departments. *Journal of Public Health Management and Practice, 1,* 50-58.
Turnock, B.J., & Handler, A.S. (1997). From measuring to improving public health practice. *Annual Review of Public Health, 18,* 261-82.
Turnock, B.J., & Hutchison, K.D. (2000). *The local public health workforce: Size, distribution, composition, and influence on core function performance, Illinois 1998-1999.* Illinois Center for Health Workforce Studies.
University of Michigan/Center of Excellence in Public Health Workforce Studies, University of Kentucky/Center of Excellence in Public Health Workforce Research and Policy. (2012). *Strategies for enumerating the U.S. government public health workforce.* Atlanta, GA: US Department of Health and Human Resources, Centers for Disease Control and Prevention.
U.S. Department of Health and Human Services, US Public Health Service. (1997). *The public health workforce: An agenda for the 21st century*. Washington, DC: U.S. Government Printing Office.
U.S. Department of Health and Human Services. (2009). *Fiscal year 2010 budget in brief.* Washington, DC: US Department of Health and Human Services.
Wiesler, B., & McGauran, N. (2010). Reporting a systematic review. *CHEST, 137,* 1240-1246.

Table 2.1. Systematic review search results by database

Search Term	PubMed	Web of Science	ERIC	Google	Articles Chosen
Public health workforce	20031	620	23	109,890	174
Public health workforce development	2874	302	10	9,370	35
Public health workforce enumeration	17	5	0	128	9
Public health workforce capacity	988	130	3	101	38
Public health workforce policy	1949	249	9	10,300	36
Public health infrastructure	5966	1694	13	157,000	49
Public health workforce performance measures	134	12	0	0	6
Public health workforce composition	193	20	0	5	5
Total articles chosen	236	72	0	44	352
Duplicate and non-relevant articles removed	135	59	---	1	195
Final total of articles chosen	101	13	0	43	157

Figure 2.1. Screening process for systematic review

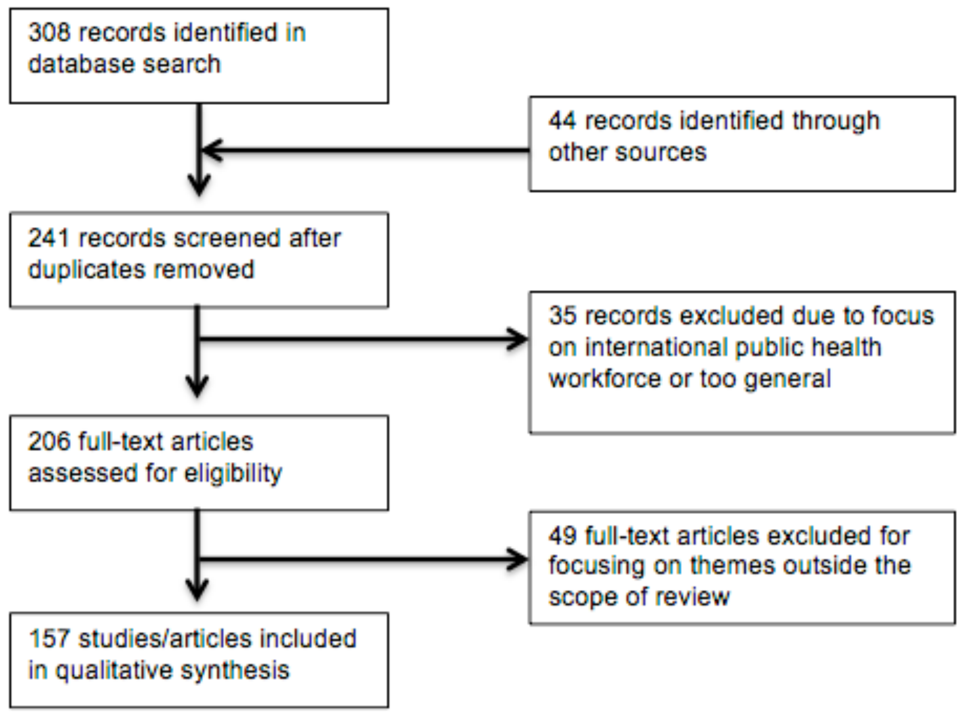
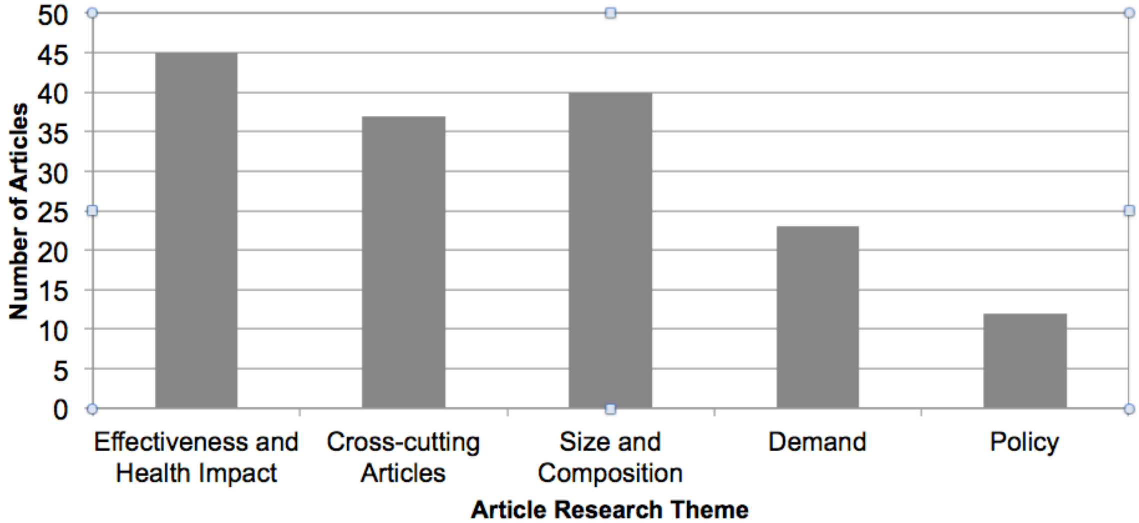


Figure 2.2. Number of articles included in systematic review by research theme (n=157)



Chapter II Appendix

List of References Included in Systematic Review (157 Articles)

American Public Health Association. (2011). *The Affordable Care Act's public health workforce provisions: Opportunities and challenges.* Washington, DC: APHA.

Asch, B.J., Haider, S.J., Zissimopoulos, J.M. (2009). The effects of workforce-shaping tools on retirement: the case of the department of defense civil service. *Journal of Public Health Management and Practice, 15,* S64-S72.

Association of Schools of Public Health. (2008). *Policy brief: Confronting the public health workforce crisis*. Washington, DC: ASPH.

Association of State and Territorial Health Officials. (2004). *State public health employee worker shortage report: A civil service recruitment and retention crisis.* Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2005). *Strategies for enumerating the public health workforce.* Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2006). *Issue brief: Public health workforce challenges: Public health epidemiologists*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2007). *2007 state public health workforce survey results*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2007). *State public health workforce brief: 2007 workforce trends profile*. Washington, DC: ASTHO.

Association of State and Territorial Health Officials. (2011). *2010 profile of state public health*. Washington, DC: ASTHO.

Atchison, C., Gebbie, K., Thielen, L., Woltring, C. (2001). *Enumerating the public health workforce*. Public Health Leadership Society/Center for Health Leadership & Practice.

Baker, E.L., Potter, M.A., Jones, D.L., Mercer, S.L., Cioffi, J.P., Green, L.W., … Fleming, D.W. (2005). The public health infrastructure and our nation's health. *Annual Review of Public Health, 26,* 303-18.

Baker, E.L. & Koplan, J.P. (2002). Strengthening the nation's public health infrastructure: historic challenge, unprecedented opportunity. *Health Affairs, 21,* 15-27.

Balcazar, H., Rosenthal, E.L., Brownstein, J.N., Rush, C.H., Matos, S., & Hernandez, L. (2011). Community health workers can be a public health force for change in the United States: three actions for a new paradigm. *American Journal of Public Health, 10,* 2199-2203.

Bales, M.E., Johnson, S.B., Keeling, J.W., Carley, K.M., Kunkel, F., & Merrill, J.A. (2011). Evolution of coauthorship in public health services and systems research. *American Journal of Preventive Medicine, 41,* 112-117.

Barry, M., & Bialek, R. (2004). Tracking our investments in public health: what have we learned? *Journal of Public Health Management and Practice*, *10,* 383-92.

Beck, A.J., Boulton, M.L., Lemmings, J., & Clayton, J.L. (2012). Challenges to recruitment and retention of the state health department epidemiology workforce. *American Journal of Preventive Medicine, 42,* 76-80.

Beckett, A.B., Scutchfield, F.D., Pfeifle, W., Hill, R., & Ingram, R.C. (2008). The forgotten instrument: analysis of the national public health performance standards program governance instrument. *Journal of Public Health Management and Practice, 14,* 17-22.

Birch, S., Kephart, G., Murphy, G.T., O'Brien-Pallas, L., Alder, R., & MacKenzie, A. (2009). Health human resources planning and the production of health: development of an extended analytical framework for needs-based health human resources planning. *Journal of Public Health Management and Practice, 15,* S56-S61.

Boulton, M.L. (2009). Toward a more analytic framework for public health workforce research. *Journal of Public Health Management and Practice, 15,* S62-S63.

Boulton, M.L., Lemmings, J., & Beck, A.J. (2009). Assessment of epidemiology capacity in state health departments, 2001-2006. *Journal of Public Health Management and Practice, 15,* 328-336.

Boulton, M.L., Hadler, J., Beck, A.J., Ferland, L., & Lichtveld, M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Report, 126,* 84-93.

Brownson, R.C., & Kreuter, M.W. (1997). Future trends affecting public health: challenges and opportunities. *Journal of Public Health Management and Practice, 3,* 49-60.

Brownson, R.C., Samet, J.M., & Thacker, S.B. (2002). Commentary: What contributes to a successful career in epidemiology in the United States. *American Journal of Epidemiology, 156,* 60-67.

Buerhaus, P.I. (2009). The shape of recovery: economic implications for the nursing workforce. *Nursing Economics, 27,* 338-340, 336.

Buerhaus, P.I. (2002). Current and future state of the US nursing workforce. *Journal of the American Medical Association, 300,* 2422-2424.

Buss, B.F., Safranek, T.J., & Foley, B.P. (2011). Statewide applied epidemiology workforce capacity and competency assessment- Nebraska, 2008. *Journal of Public Health Management and Practice, 17,* 110-121.

Centers for Disease Control and Prevention. (2001). *Public health's infrastructure: a status report.* Atlanta, GA: CDC.

Centers for Disease Control and Prevention. (2003). Assessment of epidemiology capacity in state and territorial health departments- United States 2001. *MMWR Morbidity and Mortality Weekly Reports, 52,* 1049-1051.

Centers for Disease Control and Prevention. (2009). Assessment of epidemiology capacity in state health departments- United States. *MMWR Morbidity and Mortality Weekly Reports, 58,* 1373-1377.

Centers for Disease Control and Prevention. (2011). Food safety epidemiology capacity in state health departments- United States, 2010. *MMWR Morbidity and Mortality Weekly Reports, 60,* 1701-1704.

Centers for Disease Control and Prevention. (2011). Local health department costs associated with response to a school-based pertussis outbreak- Omaha, Nebraska, September-November 2008. *MMWR Morbidity and Mortality Weekly Reports, 60,* 5-9.

Cioffi, J.P., Lichtveld, M.Y., & Tilson, H. (2004). A research agenda for public health workforce development. *Journal of Public Health Management and Practice, 10,* 186-192.

Council of State Governments. (2002). *Public health worker shortages.* Lexington, KY: Council of State Governments.

Council of State and Territorial Epidemiologists. (2002). *National assessment of epidemiologic capacity in maternal and child health: Findings and recommendations*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2004). *2004 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2006). *2006 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2006). *Public health epidemiology: Capacity at a crossroads*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2010). *2009 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2011). *2010 food safety epidemiology capacity assessment.* Atlanta, GA: CSTE.

Crawford, C.A.G., Summerfelt, W.T., Roy, K., Chen, Z., Meltzer, D.O., & Thacker, S.B. (2009). Perspectives on public health workforce research. *Journal of Public Health Management and Practice, 15,* S5-S15.

Cromwell, J., Rosenbach, M.L., Pope, G.C., Butrica, B., & Pitcher, J.D. (1991). CRNA manpower forecasts: 1990-2010. *Medical Care, 29,* 628-44.

Dannenberg, A.L., Bhatia, R., Cole, B.L., Dora, C., Fielding, J.E., Kraft, K, …. Tilson, H.H. (2006). Growing the field of health impact assessment in the United States: an agenda for research and practice. *American Journal of Public Health, 96,* 262-70.

Drabczyk, A., Epstein, P., & Marshall, M. (2012). A quality improvement initiative to enhance public health workforce capabilities. *Journal of Public Health Management and Practice, 18,* 95-99.

Draper, D.A., Hurley, R.E., & Lauer, J.R. (2008). Public health workforce shortages imperil nation's health. *HSC Research Brief, April,* 1–8.

Elkhuizen, S.G., Bor, G., Smeenk, M., Klazinga, N.S., & Bakker, P.J.M. (2007). Capacity management of nursing staff as a vehicle for organizational improvement. *BMC Health Services Research, 7,* 196.

Erwin, P.C., Greene, S.B., Mays, G.P., Ricketts, T.C., & Davis, M.V. (2011). The association of changes in local health department resources with changes in state-level health outcomes. *American Journal of Public Health, 101,* 609-615.

Fraser, M.R. (2003). The local public health agency workforce: research needs and practice realities. *Journal of Public Health Management and Practice, 9,* 496-99.

Gebbie, K.M. (1999). The public health workforce: key to public health infrastructure. *American Journal of Public Health, 89,* 660-661.

Gebbie, K.M. & Merrill, J. (2001). Enumeration of the public health workforce: developing a system. *Journal of Public Health Management and Practice, 7,* 8-16.

Gebbie, K.M., Merrill, J., & Tilson, H.H. (2002). The public health workforce. *Health Affairs, 21,* 57-67.

Gebbie, K., Merrill, J., Hwang, I., Gebbie, E.N., & Gupta, M. (2003). The public health workforce in the year 2000. *Journal of Public Health Management and Practice, 9,* 79-86.

Gebbie, K.M., & Turnock, B.J. (2006). The public health workforce 2006: new challenges. *Health Affairs, 25,* 923–932.

Gebbie, K.M., Merrill, J., Sanders, J., Gebbie, E.N., & Chen, D.W. (2007). Public health workforce enumeration: Beware the "quick fix". *Journal of Public Health Management and Practice*, *13,* 72-79.
Gebbie, K.M., Raziano, A., & Elliott, S. (2009). Public health workforce enumeration. *American Journal of Public Health, 99,* 786-787.
George, L.S., Fulop, M., & Wickham, L. (2007). Building capacity of environmental health services at the local and national levels with the 10-essential services framework. *Journal of Environmental Health, 70,* 17-20, 63.
George, A., Springer, C., & Haughton, B. (2009). Retirement intentions of the public health nutrition workforce. *Journal of Public Health Management and Practice, 15,* 127-134.
Gibbs, M. (2009). The personnel economics approach to public workforce research. *Journal of Public Health Management and Practice, 15*, S73-S78.
Goodin, H.J. (2009). The nursing shortage in the United States of America: an integrative review of the literature. *Journal of Advanced Nursing, 43,* 335-350.
Gunn, R.A., White, M.C., Miller, G.B., Conrad, J.L., & Tyler, C.W. (1989). State epidemiology programs and state epidemiologists: results of a national survey. *Public Health Reports, 104,* 170-177.
Hajat, A., Stewart, K., & Hayes, K.L. (2003). The local public health workforce in rural communities. *Journal of Public Health Management and Practice, 9,* 481-488.
Handler, A.S., & Turnock, B.J. (1996). Local health department effectiveness in addressing the core functions of public health: essential ingredients. *Journal of Public Health Policy*, *17,* 460-483.
Handler, A., Kennelly, J., & Rosenberg, D. (2001). Building the analytic capacity of the state maternal and child health workforce. *Journal of Public Health Management and Practice, 7,* 83-90.
Handler, A., Issel, M., & Turnock, B. (2001). A conceptual framework to measure performance of the public health system. *American Journal of Public Health, 91,* 1235-1239.
Handler, A., Grason, H., Ruderman, M., Issel, M., & Turnock, B. (2002). Assessing capacity and measuring performance in maternal and child health. *Maternal and Child Health Journal, 6,* 115-26.
Haughton, B., Story, M., & Keir, B. (1998). Profile of public health nutrition personnel: challenges for population/ system-focused roles and state-level monitoring. *Journal of the American Dietetic Association, 98,* 664-670.
Haughton, B. & George, A. (2008). The public health nutrition workforce and its future challenges: the US experience. *Public Health Nutrition, 11,* 782-91.
Health Resources and Services Administration. (2000). *The public health workforce: Enumeration 2000*. Washington, DC: US Department of Health and Human Services.
Health Resources and Services Administration. (2001). *The key ingredient of the national prevention agenda: Workforce development*. Washington, DC: US Department of Health and Human Services.
Health Resources and Services Administration. (2005). *Public health workforce*. Washington, DC: US Department of Health and Human Services.

Hoffman, R.E., Greenblatt, J., Matyas, B.T., Sharp, D.J., Esteban, E., Hodge, K., & Liang, A. (2005). Capacity of state and territorial health agencies to prevent foodborne illness. *Emerging Infectious Disease, 11,* 11-16.

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

Institute of Medicine. (2011). *For the public's health: The role of measurement in action and accountability.* Washington, DC: The National Academies Press.

Jarman, D.W., Liang, J.L., Luce, R.R., Wright, J.G., Stennies, G.M., Bisgard, K.M. (2011). Veterinary public health capacity in the United States: opportunities for improvement. *Public Health Reports, 126*, 868-874.

Juzych, N.S., Resnick, B., Streeter, R., Herbstman, J., Zablotsky, J., Fox, M., & Burke, T.A. (2007). Adequacy of state capacity to address noncommunicable disease clusters in the era of environmental public health tracking. *American Journal of Public Health*, *97,* S163-69.

Kennedy V.C., Spears W.D., Loe H.D., & Moore F.L. (1999). Public health workforce information: a state-level study. *Journal of Public Health Management and Practice, 5,* 10-19.

Kennedy, V.C. (2009). Public health workforce employment in US public and private sectors. *Journal of Public Health Management and Practice, 15,* E1-8.

Kufel, J.Z., Resnick, B.A., Fox, M., Frattaroli, S., Gielen, A., & Burke, T.A. (2011). Local food protection and safety infrastructure and capacity: a Maryland case study. *Journal of Public Health Management and Practice, 17,* 534-41.

Kufel, J.Z., Resnick, B.A., Fox, M., McGready, J., Yager, J.P., & Burke, T.A. (2011). The impact of local environmental health capacity on foodborne illness morbidity in Maryland. *American Journal Public Health, 101,* 1495-1500.

LaFond, A.K., Brown, L., & Macintyre, K. (2002). Mapping capacity in the health sector: a conceptual framework. *International Journal of Health Planning Management, 17,* 3-22.

Larkin, M. (2011). Public health vets want more to join their ranks. *Journal of the American Veterinary Medical Association, 239,* 35-36.

Lenaway, D., Halverson, P., Sotnikov, S., Tilson, H., Corso, L., & Millington, W. (2006). Public health systems research: setting a national agenda. *American Journal of Public Health, 96,* 410-413.

Lichtveld, M.Y. & Cioffi, J.P. (2003). Public health workforce development: progress, challenges, and opportunities. *Journal of Public Health Management and Practice, 9,* 443-50.

Lichtveld, M.Y., Cioffi, J., Henderson, J., Sage, M., & Steele, L. (2003). Editorial. People protected – public health prepared through a competent workforce. *Journal of Public Health Management and Practice, 9,* 340-343.

Lichtveld, M.Y., Boulton, M.L., Lemmings, J., & Gale, J. (2008). From competencies to capacity: assessing the national epidemiology workforce. *Public Health Reports*, *123,* 128-135.

Lichtveld, M.Y., Cioffi, J.P., Baker, E.L., Bailey, S.B., Gebbie, K., Henderson, J.V. … Tilson, H. (2001). Partnership for front-line success: a call for a national action agenda on workforce development. *Journal of Public Health Management and Practice, 7,* 1-7.

Madamala, K., Sellers, K., Beitsch, L.M., Pearson, J., & Jarris, P.E. (2011). Structure and functions of state public health agencies in 2007. *American Journal of Public Health, 101,* 1179-1186.

Mahan, C.S. & Malecki, J.M. (2004). Confronting the impending public health workforce crisis in America: perspectives from academic and public health practice. *Florida Public Health Review, 1,* 4-7.

Mason, T., Wilkinson, G.W., Nannini, A., Martin, C.M., Fox, D.J., & Hirsch, G. (2011). Winning policy change to promote community health workers: lessons from Massachusetts in the health reform era. *American Journal Public Health, 101,* 2211-2216.

Matthews, G.W., Markiewicz, M., & Beitsch, L.M. (2012). Legal frameworks supporting public health department accreditation: lessons learned from 10 states. *Journal of Public Health Management and Practice, 18,* E8-E16.

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,* 256-265.

Meit, M. (2009). The emergence of local governmental public health: Practice standards and workforce implications. *Journal of Public Health Management and Practice, 15,* S31-S32.

Meltzer, D.O. (2009). Social science insights into improving workforce effectiveness: examples from the developing field of hospital medicine. *Journal of Public Health Management and Practice, 15,* S18-S23.

Merrill, J., Btoush, R., Gupta, M., & Gebbie, K. (2009) A history of public health workforce enumeration. *Journal of Public Health Management and Practice, 9,* 459-70.

Merrill, J., Keeling, J., & Gebbie, K. (2009). Toward standardized, comparable public health systems data: a taxonomic description of essential public health work. *Health Services Research, 44,* S1818-S1842.

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

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

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

Milne, T.L. (2000). Strengthening local public health practice: a view to the millennium. *Journal of Public Health Management and Practice, 6,* 61-66.

Miner, K.R., Childers, W.K., Alperin, M., Cioffi, J., & Hunt, N. (2005). The MACH model: from competencies to instruction and performance of the public health workforce. *Public Health Reports*, *120,* 9-15.

Moore, J. Studying an ill-defined workforce: public health workforce research. (2009). *Journal of Public Health Management and Practice, 15,* S48-S53.

National Association of County Health Officials. (1990). *National profile of local health departments*. Washington, DC: NACHO.

National Association of County and City Health Officials. (2005). *2005 national profile of local health departments.* Washington DC: NACCHO.

National Association of County and City Health Officials. (2005). *The local health department workforce: Findings from the 2005 national profile of local health departments study.* Washington, DC: NACCHO.
National Association of County and City Health Officials. (2008). *2008 national profile of local health departments.* Washington DC: NACCHO.
National Association of County and City Health Officials. (2011). *2010 national profile of local health departments.* Washington, DC: NACCHO.
National Association of County and City Health Officials. (2011). *Local public health workforce benchmarks.* Washington, DC: NACCHO.
National Association of County and City Health Officials. (2011). *Describing the local public health workforce: Workers who prevent, promote, and protect the nation's health.* Washington, DC: NACCHO.
National Association of County and City Health Officials. (2003). Workforce development at the local level: the NACCHO perspective. *Journal of Public Health Management and Practice, 9,* 440-442.
New York State Public Health Workforce Task Force. (2006). *Roadmap: Strengthening the public health workforce in New York state*. Albany, NY: New York State Public Health Workforce Task Force.
North Carolina Center for Public Health Preparedness. (2007). *Public health workforce assessment report*. Chapel Hill, NC: University of North Carolina-Chapel Hill.
Northwest Center for Public Health Practice. (2002). *Building workforce bridges across northwest states: A regional analysis of workforce assessments from six NW states.* Seattle, WA: University of Washington.
Nu'man, J., King, W., Bhalakia, A., & Criss, S. (2007). A framework for building organizational capacity integrating planning, monitoring, and evaluation. *Journal of Public Health Management and Practice, 13,* S24-32.
Patton, D., Moon, C.E., & Jones, J. (2011). Describing local boards of health: insights from the 2008 National Association of Local Boards of Health Survey. *Public Health Reports, 126,* 410-419.
Popovic, T. (2009). Workforce science: a critical component to ensuring future of health. *Journal of Public Health Management and Practice, 15,* S3-S4.
Porter, D., Hall, M., Hartl, B., Raevsky, C., Peacock, R., Kraker, D., Walls, S., & Brink, G. (2011). Local health department 2009 H1N1 influenza vaccination clinics- CDC staffing model comparison and other best practices. *Journal of Public Health Management and Practice, 17,* 530-533.
Potter, M.A., Barron, G., & Cioffi, J.P. (2003). A model for public health workforce development using the national public health performance standards program. *Journal of Public Health Management and Practice, 9,* 199-207.
Potter, M.A., Ley, C.E., Fertman, C.I., Eggleston, M.M., & Duman, S. (2003). Evaluating workforce development: perspectives, processes, and lessons learned. *Journal of Public Health Management and Practice, 9,* 489-495.
Resnick, B.A., Zablotsky, J., & Burke, T.A. (2009). Protecting and promoting the nation's health: the environmental public health workforce as a critical component. *Journal of Public Health Management and Practice, 15,* S40-S45.
Roemer, M.I. (1986). The need for professional doctors of public health. *Public Health Reports, 101,* 21-29.

Roper, W.L., Baker, E.L., Dyal, W.W., & Nicola, R.M. (1992). Strengthening the public health system *Public Health Reports, 107,* 609-15.

Rosenthal, E.L., Wiggins, N., Ingram, M., Mayfield-Johnson, S., & De Zapien, J.G. (2011). Community health workers then and now: an overview of national studies aimed at defining the field. *Journal of Ambulatory Care Management, 34,* 247-259.

Roy, K., Chen, Z., & Crawford, C.A.G. (2009). Economic perspective on strategic human capital management and planning for the Centers for Disease Control and Prevention. *Journal of Public Health Management and Practice, 15,* S79-S89.

Ruderman, M., & Grason, H. (2002). Public health workforce development: keeping population health goals in mind. *Journal of Public Health Management and Practice, 8,* 84-86.

Salinsky, E., & Gursky, E.A. (2006). The case for transforming governmental public health. *Health Affairs, 25,* 1017-1028.

Salive, M.E. (1988). Shortage of preventive medicine physicians. *NY State Journal of Medicine, 88,* 441.

Scutchfield, F.D., Quimson, S., Williams, S.J., & Hofsetter, R. (1988). The demand for doctorally prepared public health personnel in institutions of higher education. *American Journal of Preventive Medicine, 4,* 298-301.

Scutchfield, F.D., Knight, E.A., Kelly, A.V., Bhandari, M.W., & Vasilescu, I.P. (2004). Local public health agency capacity and its relationship to public health system performance. *Journal of Public Health Management and Practice, 10,* 294-315.

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,* 155-166.

Scutchfield, F.D. (2009). Current reflections on the state of the public health workforce. *Journal of Public Health Management and Practice, 15,* S24-S25.

Scutchfield, F.D., Bhandari, M.W., Lawhorn, N.A., Lamberth, C.D., & Ingram, R.C. (2009). Public health performance. *American Journal of Preventive Medicine*, *36,* 266-272.

Sexton, K., & Perlin, S.A. (1990). The federal environmental health workforce in the United States. *American Journal of Public Health, 80,* 904-905.

Snider, D.E., & Stroup, D.F. (1997). Defining research when it comes to public health. *Public Health Reports*, *112,* 29-32.

Stamas, G. & Wiatrowski, W. (2009). Use of bureau of labor statistics data for characterizing the public health workforce. *Journal of Public Health Management and Practice, 15,* S54-S55.

Starr, P. (2009). Professionalization and public health: historical legacies, continuing dilemmas. *Journal of Public Health Management and Practice, 15,* S26-S30.

State of Washington. (2000). *Workforce planning guide*. Olympia, WA: State of Washington Department of Personnel.

Suarez, V., Lesenski, C., & Denison, D. (2011). Making the case for using financial indicators in local public health agencies. *American Journal of Public Health, 101,* 419-425.

Sumaya, C.V. (2012). Enumeration and composition of the public health workforce: challenges and strategies. *American Journal of Public Health, 102,* 469-474.

Summerfelt, W.T., Tilson, H.H., & Crawford, C.A.G. (2009). Moving forward with workforce development research in public health. *Journal of Public Health Management and Practice, 15,* S1-S2.

Thacker, S.B. (2009). Guide for applied public health workforce research: an evidence-based approach to workforce development. *Journal of Public Health Management and Practice, 15,* S109-S112.

Tilson, H.H., & Gebbie, K.M. (2001). Public health physicians: an endangered species. *American Journal of Preventive Medicine, 21,* 233-240.

Tilson, H. & Berkowitz, B. (2006). The public health enterprise: Examining our twenty-first-century policy challenges. *Health Affairs, 25,* 900-910.

Tilson, H. & Gebbie, K.M. (2004). The public health workforce. *Annual Review of Public Health*, *25,* 341-356.

Tilson, H.H. (2009). Wanted: The workforce to work on the workforce agenda. *Journal of Public Health Management and Practice, 15,* S16-S17.

Tomar, S.L. (2006). An assessment of the dental public health infrastructure in the United States. *Journal of Public Health Dentistry, 66,* 5-16.

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*, *109,* 653-658.

Turnock, B.J., Handler, A., Hall, W., Lenihan, P., & Vaughn, E. (1995). Capacity-building influences on Illinois local health departments. *Journal of Public Health Management and Practice, 1,* 50-58.

Turnock, B.J., & Handler, A.S. (1997). From measuring to improving public health practice. *Annual Review of Public Health, 18,* 261-282.

Turnock, B.J., & Hutchison, K.D. (2000). *The local public health workforce: Size, distribution, composition, and influence on core function performance, Illinois 1998-1999.* Illinois Center for Health Workforce Studies.

Turnock, B.J. (2009). Public health workforce trends since 1980: Myth or reality? *Journal of Public Health Management and Practice, 15,* 105-108.

Umble, K.E., Baker, E.L., & Woltring, C. (2011). An evaluation of the National Public Health Leadership Institute- 1991-2006: Part I. Developing individual leaders. *Journal of Public Health Management and Practice, 17,* 202-213.

Umble, K.E., Baker, E.L., Diehl, S.J., Steffen, D., Frederick, S., Woltring, C. (2011). An evaluation of the National Public Health Leadership Institute- 1991-2006: Part II. Strengthening public health leadership networks, systems and infrastructure. *Journal of Public Health Management and Practice, 17,* 214-224.

University of Albany School of Public Health Center for Health Workforce Studies. (2008). *Toward a methodology for substate projections of registered nurse supply and demand in New York.* Rensselaer, NY: University of Albany.

University of Michigan/Center of Excellence in Public Health Workforce Studies, University of Kentucky/Center of Excellence in Public Health Workforce Research and Policy. (2012). *Strategies for enumerating the U.S. government public health workforce.* Atlanta, GA: US Department of Health and Human Resources, Centers for Disease Control and Prevention.

Van Wave, T., Scutchfield, F.D., & Honore, P.A. (2010). Recent advances in public health systems research in the United States. *Annual Review of Public Health*, *31,* 283-295.

Viverette, M.A., Leaning, J., Steeg, S.K., Gebbie, K.M., & Litchveld, M. (2003). Who will keep the public healthy? Assuring a legally prepared workforce. *Journal of Law, Medicine, and Ethics, 31,* S81-S83.

Washington State Department of Health. (2004). *Everybody counts: The public health workforce in Washington State*. Olympia, WA: Washington State Department of Health.

Williams, S.J., Tyler, C.W., Clark, L., Coleman, L., & Curran, P. (1988). Epidemiologists in the United States: an assessment of the current supply and anticipated need. *American Journal of Preventive Medicine, 4,* 231-238.

CHAPTER III

Assessing Multi-level Predictors of Worker Competence for State Health Department Epidemiologists

Introduction

As evidenced by findings of the systematic review in Chapter II, the public health literature lacks studies that measure and predict workforce effectiveness, a key factor of public health organizations that impacts their ability to perform the Essential Public Health Services (EPHS) and improve population health outcomes. The importance of a highly-trained, competent public health workforce has been emphasized as a critical component of effective public health service delivery by the Institute of Medicine (IOM) (IOM, 1988; IOM, 2003). A 1988 IOM report stated that most public health workers have no formal training in public health [p. 16] and urged U.S. schools of public health to develop short courses for public health workers to increase their competence [p.17].

In response to the IOM recommendations, the U.S. Department of Health and Human Services has undertaken efforts to increase public health worker competence for over a decade through the funding of numerous training centers at schools of public health, such as Public Health Training Centers and the former Centers for Public Health Preparedness, which focused on assessing training needs of the public health workforce and developing competency-based continuing education courses to meet those needs (HRSA, 2011; CDC, 2011). Similarly, the federally-supported Preventive Medicine Residencies aim to train physicians for careers in public health through specialized curricula and practicum requirements (Boulton, Montgomery & Beck, 2008). Although evaluation reports indicate that these programs are useful, empirical studies that show what factors influence worker competence, and whether higher competence results in enhanced job performance, enhanced organizational capacity and improved population health have not been published.

The national focus on competencies, defined as clusters of related knowledge, skills, and attitudes affecting a major part of one's job that are correlated with job performance, measured against well-accepted standards, and improved through training and development (Lucia & Lepsinger, 1999; Miner, Childers, Alperin, Cioffi & Hunt, 2005), has resulted in the development of several competency sets for public health workers. The Council on Linkages Between Academia and Practice developed the Core Competencies for Public Health Professionals in 2001 and has since adopted iterative revisions to assess the skills of public health workers (Council on Linkages, 2010; Gebbie & Turnock, 2006). Similarly, competency sets were developed for emergency preparedness (Gebbie & Merrill, 2002), public health leadership (Wright et al., 2000), public health nursing (Quad Council, 2011), and applied epidemiology (CDC/CSTE, 2008), among others. The Applied Epidemiology Competencies (AECs) are used in this study.

The premise of this study stipulates that mastery of competencies results in higher worker competence, which has been defined as "personality characteristics associated with superior performance and high motivation" (Le Diest & Winterton, 2005, p.31; White, 1959). The purpose of this paper is to identify individual-level characteristics of workers and organizational-level characteristics of health departments that significantly correlate with self-assessed worker competency scores. Health care literature suggests that organizational factors, including staffing characteristics, may be related to worker performance and organizational outcomes (Lundstrom, Pugliese, Bartley, Cox & Guither, 2002). However, the public health literature does not address whether these or other characteristics of health departments support a more competent and effective workforce, or provide evidence-based findings that describe individual-level characteristics that are significantly associated with competence.

I used competency scores self-reported by epidemiologists working in state health departments, and variables that describe characteristics of the workers and the health departments they work in for this study, which was guided by the following research questions: 1) what individual-level characteristics of workers significantly predict self-assessed competence; 2) what organizational-level characteristics of health departments predict average worker competency scores; and 3) do individual-level and organizational-level characteristics that predict worker competence vary by epidemiologist job tier?

Study hypotheses suggested significant individual-level positive predictors of self-assessed competence included educational background (i.e., highest degree obtained), having a graduate degree in epidemiology, having 5 or more years of experience as an epidemiologist, and job tier (i.e., entry-level, mid-level, or senior-level worker). These hypotheses were based on concepts of human capital theory, which proposes that education, work experience, and on-the-job training are positively associated with worker capabilities and workforce capacity, and suggests that organizational investment in worker education and training results in a more productive workforce (Sweetland, 1996; Benson, 1978; Mincer, 1974; Schultz, 1971). In addition, study findings have shown that competence is associated with worker skills, knowledge, personal characteristics and behaviors (Le Diest & Winterton, 2005). The data set does not provide information on personal characteristics such as demographics, attitudes, and behaviors; therefore, the individual-level variables used in the analyses are more directly related to skills and knowledge. Organizational-level variables hypothesized to be significantly positively associated with worker competence included the extent to which training opportunities are made available to workers by the health department, the size of the epidemiology workforce employed by the health department, and the organizational capacity of the health department to deliver epidemiology-related EPHS, as assessed by the State Epidemiologist. These hypotheses consider organizational characteristics noted in the public health literature as being important for workforce development (Cioffi, Lichtveld & Tilson, 2004).

Methods

Data for the study come from a subset of the Council of State and Territorial Epidemiologists' (CSTE) 2009 Epidemiology Capacity Assessment (ECA), the latest in a series of four periodic assessments and one of the few public health workforce data sources to collect individual-level and organizational-level data. The purpose of the ECA is to collect data to enumerate and describe epidemiologists employed in state and territorial health departments, measure the extent to which state health departments are capable of performing epidemiologic activities by public health program area, reassess competency-specific training needs and barriers to recruiting and retaining epidemiologists, and assess the quality and use of surveillance system technology (CSTE, 2010).

The full ECA data set includes individual-level variables collected for workers employed as epidemiologists in state or territorial health departments, such as educational background, program area, job experience, retirement plans, and competency level, as well as organizational-level data reported by the State Epidemiologist including program and EPHS capacity, supervisory structure, funding sources, number of epidemiologists, number of additional epidemiologists needed, educational background of workforce, workforce recruitment and retention factors (CSTE, 2010; Boulton, Hadler, Beck, Ferland & Lichtveld, 2011). Variables related to workforce size, education, experience, and training opportunities were used in this secondary data analysis, as were measures of EPHS capacity. In addition, I used state population size and state health department governance structure data from the Association of State and Territorial Health Officials (ASTHO) 2010 Profile of State Public Health Survey (ASTHO, 2011).

In this analysis, I used a sample subset of 1,442 workers nested in 44 state health departments. Data from territorial health departments were excluded due to low response rates. Additionally, 100 workers were removed from the data set prior to analysis because they lacked self-assessed competency data, which was used as the outcome variable. Finally, 23 more workers were removed via listwise deletion during the analysis due to inadequate competency data (i.e., more than one quarter of the competencies used in the analysis were not scored) and 16 workers were omitted from the analysis for having missing educational data, leaving a total of 1,403 workers in 44 health departments. The following measures were used to test the study hypotheses; descriptive statistics, including means, standard deviations (SD) and frequency distributions were reviewed and assumptions were evaluated for all individual-level and organizational-level variables using SPSS REGRESSION and SPSS EXPLORE.

Measures Collected at the Individual Level

Competency Score: Each epidemiologist rated themselves on a series of 30 to 32 AECs (CDC/CSTE, 2008), which varied by job tier levels of entry-level (Tier 1), mid-level (Tier 2), or senior-level (Tiers 3a and 3b). Ratings were on a 5-point scale with 1 being equivalent to "no training" and 5 being equivalent to "competent/expert". Sixteen competencies either identical or closely related across job categories were chosen for the analysis to ensure a common set of competencies were used as the outcome variable for all epidemiologists in the study (Table 3.1). All 16 competencies were verified to load onto one latent factor through a factor analysis with no rotation using SPSS FACTOR (results not shown). Responses were averaged to calculate a composite competency score for each epidemiologist.

The AECs group competencies into 8 domain areas: assessment and analysis; basic public health sciences; communication; community dimensions of practice; cultural competency; financial and operational planning and management; leadership and systems thinking; and policy development. CSTE chose to include a select number of competencies from each domain area in the 2009 ECA. In general, chosen competencies were heavily skewed toward the assessment and analysis domain, which represented between 28%-67% of the surveyed competencies, depending on the job tier. Basic public health sciences and communication domains were emphasized for Tier 1 and Tier 2 epidemiologists in the ECA, while a higher proportion of competencies in financial and operational planning and leadership and systems thinking domains were included for Tier 3a and Tier 3b job tiers.

In comparison, the composite survey variable used in this study also heavily represents competencies in the assessment and analysis domain, as at least 50% of the 16 competencies used represent that domain for each job tier. Two to three competencies in each job tier represent the basic public health sciences and communication domains. The community dimensions of practice, cultural competency, and financial and operational planning domains are represented by one competency each. Leadership and systems thinking and policy development domains do not have competencies represented in this composite score (Table 3.2).

Job Tier: All epidemiologists selected a competency tier, coded 1 to 4 in the dataset, that best reflected the level of their current epidemiology position. As defined by the AECs, Tier 1 refers to entry-level or basic epidemiologists, whose primary functions are to carry out simple data collection, analysis, and reporting in support of surveillance and epidemiologic investigations. Tier 2 refers to mid-level epidemiologists who carry out simple and more complex and non-routine data collection, analysis, and interpretation tasks and can work independently or supervise a unit, serve as a project leader or surveillance coordinator. Tier 3a is used for senior-level epidemiologists who may be supervisors, managers, or directors of a major section, program, or bureau in a public health agency. Tier 3b is used for senior scientists or subject area experts in an epidemiologic focus area (CDC/CSTE, 2008). Tiers 3a and 3b were combined into one tier to improve the sample size of this category after ANOVA results showed no significant different in competency score between the two groups (results not shown). Two contrast variables were created for job tier in the first regression model: entry-level compared to mid-level, and mid-level compared to senior-level. Independent models were subsequently run for each of the three job tiers.

Education: Epidemiologists reported their highest degree earned, used in this study as a proxy for educational attainment, which ranged from associate's degree, bachelor's degree, RN/other nursing degree, master's degree, doctoral degree, and professional degrees such as DVM, DDS, and MD/DO. A recoded dichotomous variable was created to identify workers holding a graduate degree (i.e., associate's degree and bachelor's degree=0, master's degree and doctoral/professional degree=1). Seventeen respondents chose "RN/other nursing degree" as their highest level of education; their responses to the question about highest level of epidemiology training were reviewed to determine whether they could be assigned a value of 0 or 1. One of the 17 respondents reported a master's degree in epidemiology and was assigned a value of 1. The 16 RNs who did not hold a bachelor's, master's or doctoral degree in epidemiology, approximately 1% of the total sample, were excluded from the analysis. These epidemiologists could were not assigned a value and because Registered Nurse licensure can be obtained by varying degree levels so an assumption regarding educational level could not be made.

Epidemiology Training: Highest level of epidemiology training was reported on a scale from 1 to 8: 1= No formal training in Epidemiology; 2= On the job training; 3= Some coursework in Epidemiology; 4= Formal training program in Epidemiology (e.g. Epidemic Intelligence Service); 5= Bachelor's degree in Epidemiology; 6= Master's degree in Epidemiology; 7= Professional background with dual degree in epidemiology; 8= Doctoral degree in Epidemiology. This variable was recoded as a dichotomous variable, where 0=no epidemiology degree (i.e., responses 1-4 on the original scale), and 1=epidemiology degree (i.e., responses 5-8 on the original scale).

Experience: Epidemiologists reported whether they had at least 5 years of epidemiology job experience using a dichotomous Yes/No variable.

Measures Collected at the Organizational Level

Training: Health department support of training opportunities to enhance the competence of their workers is a key organizational-level variable in this study. In this analysis, the training variable represents the extent to which the health department supports training and professional development opportunities for staff (i.e., the number of different types of opportunities the health department supports). A composite training variable was created by summing health department responses (0=No, 1=Yes) to six questions about training opportunities related to: 1) requiring continuing education in epidemiology and surveillance; 2) including education and training objectives in performance reviews; 3) paying for formal training or education outside the organization; 4) providing on-site trainings; 5) providing epidemiology training or education to epidemiologists at the local level; and 6) having a staff position responsible for internal training.

Capacity: Capacity to perform EPHS is the average rating score provided by the State Epidemiologist for four significantly positively correlated EPHS thought to be most dependent on epidemiologists and epidemiology capacity: 1) monitoring health status to identify and solve community health problems; 2) diagnosing and investigating health problems and health hazards in the community; 3) evaluating effectiveness, accessibility and quality of personal and population-based health services; and 4) research for new insights and innovative solutions to health problems.

Ratings ranged from 0 to 5, with 0=no capacity (i.e., none of the activity, knowledge or resources described within the question are met); 1=minimal capacity (i.e., less than 25% (but greater than 0%) of the activity, knowledge or resources described within the question are met); 2= partial capacity (i.e., 25% or greater (but less than 50% of the activity, knowledge or resources described within the question are met), 3=substantial capacity (i.e., 50% or greater (but less than 75%) of the activity, knowledge or resources described within the question are met), 4=almost full capacity (i.e., 75% or greater (but less than 100%) of the activity, knowledge or resources described within the question are met), and 5= full capacity (i.e., 100% of the activity, knowledge or resources described within the question are met) (CSTE, 2010).

Workforce Size: This variable refers to the number of Full-Time Equivalent (FTE) epidemiologists employed by the state health department.

State Population Size: The size of the state's population based on 2010 census data is used as a control variable in all models because of its relationship to other variables in the models. For example, larger states are more likely to have more FTE epidemiologists compared to smaller states.

Governance Structure: The state's governance structure, as defined by ASTHO (2011), was used as a control variable in all models, where 1=Centralized/Largely Centralized, in that the state health agency retains authority over local health units; 2=Decentralized/Largely Decentralized, meaning the local health units are independent of the state health agency; 3=Shared/Largely Shared, in which local health units may be under the authority of state and local government; and 4=Mixed, where no one governance structure predominates the state. This variable was recoded into a dichotomous variable where 1= Decentralized/Largely Decentralized and 0= all other governance structures. This is a control variable because states with governance structures that are not decentralized may be more likely to report more FTE epidemiologists than decentralized states; epidemiologists working in local health departments may be employees of the state and could be reported as such in this data set, whereas states with decentralized governance structures would be unlikely to report epidemiologists working at the local level.

Analysis Methods

After descriptive statistics were reviewed, Pearson Product Moment correlations were calculated for all individual-level and organizational-level continuous variables to identify significant relationships between outcome and predictor variables and to check for multicollinearity and singularity. One assumption of concern when analyzing individual-level data is independence of observations due to the fact that workers are nested within health departments. This is important because when the multilevel structure of the data is not considered, Type I error rates may be inflated, resulting in incorrect conclusions about the relationships between variables (Tabachnick & Fidell, 2007). A fully unconditional model with no predictor variables was run using HLM version 6.08 to confirm that worker competency scores do not vary significantly across health departments, indicating that the independence of observations assumption will not be violated (results not included).

Next, a regression model was run for all 1,403 cases, controlling for job tier. Workers were also stratified by job tier and 4 subsequent standard multiple regression analyses were conducted, one for each job tier strata, using SPSS version 19. The sample size of epidemiologists in each job tier was as follows: entry-level= 305 workers; mid-level= 635 workers; senior-level= 463 workers; all sample sizes were sufficient to achieve power greater than 0.8 for standard multiple regression analyses (power=1.0, α=0.05) (Soper, 2012). This study was reviewed by the University of Michigan Institutional Review Board and deemed exempt from ongoing review.

Results

Descriptive statistics were examined for all variables. Results for the full data set with all epidemiologists were as follows: average competency score (mean=3.72; SD=0.68); level of epidemiology training (58% with epidemiology degree; SD= .49); years of work experience (67% with at least 5 years of epidemiology experience; SD=0.47); education (87% with a graduate degree; SD= 0.34); number of training opportunities (mean=3.75; SD=1.64); average EPHS capacity (mean=2.74; 1.04); number of workers (mean=65.2; 37.4); state population size (mean=11.3M; SD=9.9M) and governance structure (66% decentralized; SD=.47). In comparison, mean scores for individual-level variables such as competence, level of epidemiology training, highest level of education, and having at least 5 years of epidemiology experience increased by job tier level, with entry-level workers having mean scores below the mean for all workers; mid-level worker mean scores being approximately equal to the overall mean scores; and senior-level workers having higher scores than the overall mean. Descriptive statistics for organizational-level characteristics did not vary substantially by job tier (Table 3.3). Histograms of all variables showed they were close to normally distributed and did not require transformation. No outliers were evident in the data.

Model 1: All Epidemiologists

In the first model, there was moderate significant correlation between individual-level variables and the outcome variable of competency score, as well as moderate correlation between individual-level variables themselves. Level of epidemiology training ($r = .29$), having 5 years or more of epidemiology experience ($r = .37$), education ($r = .30$), and job tier contrast variable for tiers 1 and 2 ($r = .33$) were all positively significantly associated with worker competency scores at the $p = 0.01$ level, while the job tier contrast variable for tiers 2 and 3 was significant at the $p = 0.05$ level ($r = .06$). The only organizational-level variable with significant correlation with competency score was workforce size ($r = -.08$), which was also significant at the $p = 0.01$ level. Several individual-level variables were also significantly correlated with each other. Among those of most importance to the research questions are the significant positive correlations between level of epidemiology training and the following variables: years of epidemiology job experience ($r = .11$), education ($r = .43$), and job tier contrast variables ($r = .16$ and $r = .08$). These correlations are low to moderate (Table 3.4), but they did not remain significant in all subsequent models.

Based on the results of a one-way ANOVA, mean competency scores for all three job tiers were significantly different from each other ($p < .0001$). A standard multiple regression was performed with competency score as the dependent variable and epidemiology training (i.e., having a degree in epidemiology), having 5 or more years of experience as an epidemiologist, education (i.e., having a graduate degree), job tier, average EPHS capacity of the organization, and workforce size as independent variables; state population size, and governance structure of the agency were included as control variables. The interaction effect of experience and education was examined but was not significant so was dropped from the model. In the reduced model, R was significantly different from zero, F (10, 1392)= 67.34, $p<.01$, with R^2 of .326. The adjusted R^2 value of .321 indicates that 32.1% of the variability in worker competency scores is predicted by the independent variables. Eight of the ten regression coefficients were significantly different from zero at the $p= 0.05$ level in this model: level of epidemiology training, having 5 or more years of experience as an epidemiologist, highest degree obtained, job tier contrast variables (all at $p<.0001$), workforce size ($p=.019$), average EPHS capacity ($p=.026$), and state population size ($p=.033$) (Table 3.4). Based on their squared semi-partial correlations, .181 of the R^2 was attributable to unique sources; the remaining .145 represents variance that the eight significant variables jointly contributed to R^2.

Both standardized and unstandardized coefficients are shown in Table 3.4. Unstandardized coefficients are reported for dichotomous variables; standardized are reported for continuous variables. The unstandardized coefficients showed that workers holding an epidemiology degree had an average competency score .147 units higher compared to those without an epidemiology degree. Similarly, epidemiologists with a graduate degree had an average competency score .216 units higher than those without a graduate degree. Workers with at least 5 years of epidemiology experience had average competency scores .213 units higher than those with fewer than 5 years of experience.

The job tier contrast variables showed that worker competency scores are significantly higher in mid-level epidemiologists compared to entry-level epidemiologists (.488 units higher in mid-level); senior epidemiologists had significantly higher worker competency scores compared to mid-level epidemiologists (.217 units higher in senior level). Standardized beta weights showed that 1 SD increase in number of workers corresponded to a .077 decrease in worker competency score; a .060 decrease in worker competency score was associated with a 1 SD increase in the average capacity score of the health department; and a 1 SD increase in state population size corresponded to a .067 increase in worker competency score.

Casewise diagnostics and residual statistics tables showed no evidence of multivariate outliers, as the maximum Mahalanobis distance is less than the critical χ^2 value at α=.001 for 10 degrees of freedom. Collinearity statistics show tolerance and VIF values to be sufficient, as tolerance was far from zero and VIF was at or below 2 for all variables. Eigenvalues were above zero for several of the model dimensions and the condition index is less than 15 for nearly all model dimension, supporting the notion that collinearity was not likely a serious problem in this data set (data not shown). These statistics were similar for subsequent models.

Model 2: Entry-Level Epidemiologists (Tier 1)

Similar to Model 1, level of epidemiology training (r =.27) and educational level (r=.23) were positively significantly correlated with worker competency scores at the p= 0.01 level. Average EPHS capacity of the health department was also significantly correlated with worker competency, but had a negative association (r= -.15). Having 5 years of epidemiology experience was not significantly correlated with worker competency for this job tier (Table 3.5).

A standard multiple regression was performed with all variables included in Model 1, with the exception of job tier, for this and all subsequent models. R was significantly different from zero, $F (8, 296)= 5.673$, $p<.01$, with R^2 of .133. Based on the adjusted R^2 value, 11.0% of the variability in worker competency scores was predicted by the independent variables. Epidemiology training remained highly significant for this job tier ($p<.0001$); having 5 or more years of epidemiology experience ($p=.033$) and education ($p=.009$) were significant at the $p= 0.05$ level. The organizational-level variable of average EPHS capacity of the health department was also significant in this model ($p=.006$). Squared semi-partial correlations for these variables showed that .099 of the R^2 was attributable to unique sources, while the remaining .034 represents variance that the four significant variables jointly contributed to R^2.

Table 3.5 summarizes the regression coefficients for this model. The unstandardized coefficients show that workers with an epidemiology degree have average competency scores .369 units higher than workers who do not have a degree in epidemiology. Epidemiology job experience corresponded to a .204 unit increase in competency score compared to those without 5 years of experience, and a .250 unit increase in competency score was observed for epidemiologists holding a graduate degree. Standardized beta weights showed that 1 SD increase in the average capacity score of the health department corresponded to a .168 decrease in worker competency score.

Model 3: Mid-level Epidemiologists (Tier 2)

In the dataset for mid-level epidemiologists, two variables had positive significant correlations (p= 0.01) with competency score: level of epidemiology training (r =.11) and having 5 or more years of epidemiology job experience (r=.17) (Table 3.6). Results of the standard multiple regression showed that R was significantly different from zero, F (8, 626)= 4.29, p<.01, with R^2 of .052. The adjusted R^2 value showed that approximately 5% of the variability in mid-level epidemiologist competency scores is predicted by the independent variables in the model.

Four coefficients were significant at the p= 0.05 level, with unstandardized coefficients of the variables showing the following positive associations: level of epidemiology training (B=.109; p=.016) and having 5 or more years of epidemiology experience (B= .198; p<.0001). Two organizational-level variables had significant associations with competence: FTEs in the workforce (β= -.130; p=.028), and state population size (β= .123; p=.030) (Table 3.6). Approximately .052 of the R^2 is attributable to unique sources, while the remaining less than .001 represents the variance that the significant variables jointly contribute to R^2.

Model 4: Senior Management/Senior Scientist Epidemiologists (Tiers 3a & 3b)

Having 5 or more years of epidemiology job experience (r=.18) and educational level (r=.11) were the only variables significantly correlated (p= 0.05) with competency score in the dataset for senior epidemiologists (Table 3.7). Standard multiple regression results showed that R was significantly different from zero, F (8, 454)= 3.271, p<.01, with R^2 of .055 and adjusted R^2 value showing that 3.8% of the variability in senior manager competency scores is predicted by the independent variables in the model.

The only significant variable in the model was having 5 or more years of epidemiology job experience, which had an unstandardized coefficient of .174 ($p=<.001$). Having a graduate degree approached significance (B=.260; $p=.07$) (Table 3.7). Approximately .029 of the R^2 is attributable to unique sources, while the remaining .026 represents variance that the significant variable of education contributes to R^2. Table 3.8 summarizes the variables significantly associated with worker competency scores in each of the regression models.

Discussion

The findings of this study provide evidence to support some of the a priori hypotheses. Several significant correlations were found between the competency scores and worker characteristics, such as educational background, level of epidemiology training, and having five or more years of epidemiology job experience. The positive correlations between these variables is intuitive, as one would expect workers with higher levels of education, training, and experience to be more "competent". The regression model results indicate that different factors may influence worker competence depending on the job tier of the worker. The first model (Table 3.4), which yielded the best fit for the data, produced highly significant associations for all individual-level variables. Having at least five years of epidemiology job experience is the only variable that was significant in all models, suggesting that on-the-job experience may be the most important factor in enhancing worker competence regardless of the job tier of the epidemiologist (Table 3.8).

Overall, having a graduate degree seemed to influence worker competence less as workers move to higher job tiers. Having a degree in epidemiology and having a graduate degree in any field was not significantly associated with worker competence for senior-level epidemiologists. These results may suggest that coursework in epidemiology or other public health science subjects is essential foundational training for epidemiologists entering positions at a state health department, but not necessarily sufficient to improve competence of workers in senior-level positions. Mastery of scientific and administrative skills learned on the job appears to be a better predictor of competence in senior-level epidemiologists.

It is important to note that the composite competency variable calculated for these analyses minimized or omitted AECs used in the ECA study from the financial/operational planning and leadership and systems thinking domains in an attempt to create a comparable dependent variable across job tiers. These competencies are most relevant to senior-level epidemiologists, particularly those in managerial positions. It is possible that an averaged competency score including these domains would yield slightly different measures of association between the individual-level variables and competence.

Overall, the results of the study supported the first hypothesis that individual characteristics of epidemiologists, such as education, epidemiology training and experience, are significant predictors of worker competence and showed that the degree to which each are important may vary by the job level of the epidemiologist. The results of the study did not support all hypotheses related to organizational factors. The number and types of training opportunities offered by the health department was not a statistically significant predictor of competence in any model. One explanation for this finding could be that continuing education courses being offered to state health department epidemiologists are not intensive enough to result in substantial change in knowledge, skills, or abilities that relate to daily epidemiology work. It is also possible that the training opportunities are not based on the AECs, making significant associations between these measures unlikely. The training opportunities measure could be improved by having health departments enumerate the trainings offered to staff over a period of time and by collecting information on the type, quality and intensiveness of trainings provided, as well as the direct applicability of the trainings to assessed competencies.

The size of the epidemiology workforce and average EPHS capacity of the health department were significantly related to competency in some of the models. Workforce size was negatively significantly associated with competence in the models for all epidemiologists and mid-level epidemiologists. The finding that greater numbers of FTE epidemiologists in the organization is associated with lower worker competence could suggest that epidemiologists with fewer co-workers are required to be competent in more areas than epidemiologists with more co-workers. In other words, epidemiologists working in health departments with a lower epidemiologist staff ratio may find it necessary to master a breadth of competencies to perform their daily work and may rate themselves as being competent in more areas, resulting in a higher overall average competency score. Epidemiologists in larger state health departments employing more epidemiology staff may have more specialized job functions and find that several of the competencies included in the survey do not directly apply to their work, and therefore report lower average scores across the sixteen competencies surveyed.

Similar findings could apply to local health departments, which tend to have far fewer epidemiologists on staff compared to state health departments (CSTE, 2010; NACCHO, 2011), making them more likely to be trained in a variety of epidemiology skills. Conversely, one might expect epidemiologists working in federal agencies to have specialized training, which could result in high competence in a few areas and lower competence in several of the areas assessed using this instrument. Future studies may want to consider analyzing the relationship between worker competence and structure of the state health department's epidemiology bureau, as previous research shows that states that place epidemiology staff in an organizational unit have more epidemiologists than states that separate epidemiologists by program area (Boulton, Lemmings & Beck, 2009). The impact of bureau structure and workforce size on worker competence has not been examined.

The significant finding of average EPHS capacity as a negative predictor of workforce competence in the entry-level and mid-level models may be best explained by examining the measurement of the capacity variable, which is a subjective qualitative measure assessed by the State Epidemiologist. It is possible that measurement error exists in this variable, resulting in a counter-intuitive result that implies that higher health department capacity is associated with lower workforce competence. Improving the accuracy of measurement of capacity would strengthen future analyses. Chapter IV of this dissertation will focus on capacity as a dependent variable to determine whether associations with other workforce variables yield similar results.

In addition to the possibility of measurement error, there are additional study limitations to note. First, although the worker competency score and average EPHS capacity variables could be considered ordinal due to the use of categorical item responses, the analyses consider these variables as continuous because the underlying scale is a 0-100 percent continuous scale, which uses consistent intervals for responses (Tabachnick & Fidell, 2007).

Second, caution should be taken in generalizing study findings to the public health workforce broadly, as this study used data specific to a small segment of the public health workforce: epidemiologists in state health departments. The individual-level survey was completed by approximately 70% of epidemiologists employed by state health departments; it is unknown whether non-respondents were significantly different from respondents. Although the exact workforce proportions for these variables (epidemiology degree, 5 years or more of experience, and job tier) at the state health department is unknown, for comparison purposes, ECA census data collected from state health departments in 2006 indicated that approximately 54% of the workforce had formal training in epidemiology and 52% of state health department epidemiologists had at least 5 years of epidemiology job experience, compared to nearly 68% for each variable in the 2009 data set. Job tier data were not collected in 2006 (CSTE, 2006). It is possible that respondents to this survey tended to be higher in education and experience than those who did not respond.

Conclusion

The purpose of this study was to identify individual-level and organizational-level predictors of worker competency scores, with the assumption that higher worker competence translates to improved job performance, which contributes to better organizational performance in delivering EPHS. The distal constructs in such a model have yet to be adequately measured in PHSSR to allow for causal relationships to be tested, which would be a promising area for future research. Although the structure of these data sets did not allow for multilevel modeling, future studies should consider testing within-health department, between-health department, and slopes-as-outcomes models to determine whether relationships between organizational and individual factors are significantly associated with individual-level outcomes.

Collection of additional data for use in future studies is important. Other research has found characteristics such as personal factors, job characteristics, and organizational factors to positively predict self-perceived competence in social workers (Kayser, Walker & Demaio, 2000). These variables could be measured and modeled in public health workforce sectors to provide a more complete picture of factors that enhance, or predict for, worker competence. In this study, the fit of the regression model was worse as level of job tier increased with less of the variance in competency score being explained by the independent variables, indicating that perhaps there are other variables at either the individual-level or organizational-level that better predict worker competence for senior epidemiologists. For example, senior managers may benefit more from training in leadership and management principles than epidemiologist principles at that stage of their career to effectively do their jobs. Finally, other variables in addition to worker competence that may impact job performance should be considered, such as job satisfaction and commitment to the organization (Glisson & Durick, 1988; Judge, Thoresen, Bono, and Patton, 2001).

The findings of this study yield important information about individual-level characteristics of epidemiologists that are associated with higher competency scores. The findings show that while academic preparation is important, efforts should be made to ensure that graduate programs training epidemiologists should incorporate as much applied, practice-based teaching as possible throughout the course of a degree program in order for entry-level epidemiologists to be well-prepared to enter the health department workforce. Additionally, the findings provide an initial profile of how a State Epidemiologist may want to ideally structure the health department's epidemiology workforce to maximize competence, including trying to ensure that all epidemiologists have formal academic training in epidemiology, entry-level epidemiologists are well-mentored upon beginning their job position, and a substantial proportion of the workforce has at least 5 years of epidemiology work experience.

Chapter III Literature Cited

Association of State and Territorial Health Officials. (2011). *2010 profile of state public health*. Washington, DC: ASTHO.

Benson, C.S. (1978). *The economics of public education* (3rd ed.). Boston: Houghton Mifflin.

Boulton M.L., Montgomery J.P., Beck A.J. (2008). Epidemiology competencies and preventive medicine residencies: do they mix and map? *Public Health Reports, 123,* 136-148.

Boulton, M.L., Lemmings, J., & Beck, A.J. (2009). Assessment of epidemiology capacity in state health departments, 2001-2006. *Journal of Public Health Management and Practice, 15,* 328-336.

Boulton, M.L., Hadler, J., Beck, A.J., Ferland, L., & Lichtveld, M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Report, 126,* 84-93.

Centers for Disease Control and Prevention. (2011). *Centers for public health preparedness*. Accessed at: http://emergency.cdc.gov/cdcpreparedness/cphp/index.asp.

Centers for Disease Control and Prevention/Council of State and Territorial Epidemiologists. (2008). *Competencies for applied epidemiologists in governmental public health agencies (AECs).* Retrieved from: http://www.cdc.gov/appliedepicompetencies/.

Cioffi, J.P., Lichtveld, M.Y., & Tilson, H. (2004). A research agenda for public health workforce development. *Journal of Public Health Management and Practice, 10,* 186-192.

Council of State and Territorial Epidemiologists. (2006). *2006 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.

Council of State and Territorial Epidemiologists. (2010). *2009 national assessment of epidemiologic capacity: Findings and recommendations*. Atlanta, GA: CSTE.

Council on Linkages Between Academia and Practice. (2010). *Core competencies for public health professionals.* Washington, DC: Public Health Foundation. Retrieved from: http://www.phf.org/resourcestools/Documents/Core_Public_Health_Competencies_III.pdf.

Gebbie, K., Merrill, J. (2002). Public health worker competencies for emergency response. *Journal of Public Health Management and Practice, 8,* 73-81.

Gebbie, K., Turnock, B.J. (2006). The public health workforce, 2006: new challenges. *Health Affairs*, *25,* 923-933.

Glisson, C., Durick, M. (1988). Predictors of job satisfaction and organizational commitment in human services organizations. *Administrative Science Quarterly, 33,* 61-81.

Health Resources and Services Administration. (2011). *National public health training centers network*. Accessed at: http://www.publichealthtrainingcenters.org/.

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

Institute of Medicine. (2003). *Who will keep the public healthy? Educating public health professionals in the 21st century.* Washington DC: National Academy Press.

Judge, T.A., Thoresen, C.J., Bono, J.E., Patton, G.K. (2001). The job satisfaction-job performance relationship: a qualitative and quantitative review. *Psychological Bulletin, 127,* 376-407.
Kayser, K., Walker, D., Demaio, J. (2000). Understanding social workers' sense of competence within the context of organizational change. *Administration in Social Work, 24,* 1-20.
Le Deist, F.D., Winterton, J. (2005). What is competence? *Human Resource Development International, 8,* 27-46.
Lucia, A.D., Lepsinger, R. (1999). *The art and science of competency models*. San Francisco, CA: Jossey-Bass.
Lundstrom, T., Pugliese, G., Bartley, J., Cox, J., Guither, C. (2002). Organizational and environmental factors that affect worker health and safety and patient outcomes. *American Journal of Infection Control, 30,* 93-106.
Mincer, J. (1974). *Schooling, experience, and earnings.* New York: Columbia University Press.
Miner, K.R., Childers, W.K., Alperin, M., Cioffi, J., Hunt, N. (2005). The MACH model: from competencies to instruction and performance of the public heath workforce. *Public Health Reports, 120,* 9-15.
National Association of County and City Health Officials. (2011). *2010 national profile of local health departments.* Washington, DC: NACCHO.
Quad Council of Public Health Nursing Organizations. (2011). *Quad Council competencies for public health nurses*. Retrieved from: http://www.astdn.org/downloadablefiles/2011%20QC%20Competencies%20PHN/Quad%20Council%20Competencies%20for%20Public%20Health%20Nurses.pdf.
Schultz, T.W. (1971). *Investment in human capital: The role of education and research.* New York: The Free Press.
Soper, D.S. (2012). *Post-hoc statistical power calculator for multiple regression* (Online Software), http://www.danielsoper.com/statcalc3.
Sweetland, S.R. (1996). Human capital theory: Foundations of a field of inquiry. *Review of Educational Research, 66,* 341-359.
Tabachnick, B.G., Fidell, L.S. (2007). *Using multivariate statistics*, 5th Ed. Boston, MA: Pearson Education, Inc.
White, R. (1959). Motivation reconsidered: the concept of competence. *Psychological Review, 66,* 279-333.
Wright, K., Rowitz, L., Merkle, A., Ried, W.M., Robinson, G., Herzog, B., ...Baker, E. (2000). Competency development in public health leadership. *American Journal of Public Health, 90,* 1202-1207.

Table 3.1. Competencies used in analysis by job tier

Tier 1: Entry-level	Tier 2: Mid-level	Tier 3a: Senior Manager	Tier 3b: Senior Scientist
Recognize the existence of a public health problem	Use critical thinking to determine whether a public health problem exists	Ensure identification of public health problems pertinent to the population	Validate identification of public health problems pertinent to the population
Identify surveillance data needs	Design surveillance for a public health issue and identify surveillance data needs	Oversee surveillance activities	Organize surveillance
Assist in design of investigation, including creating hypotheses	Assist in the design of an investigation, including hypothesis generation	Ensure investigation of acute and chronic conditions or other adverse outcomes in the population	Design investigation of acute and chronic conditions or other adverse outcomes in the population
Follow ethics guidelines and principles when planning studies, conducting research, and collecting, disseminating, and using data	Follow ethics guidelines and principles when planning studies, conducting research, and collecting, disseminating, and using data	Ensure study design and data collection, dissemination, and of use ethical and legal principles	Synthesize principles of good ethical/legal practice for application to study design and data collections, dissemination, and use
Apply knowledge of privacy laws to protect confidentiality, including Health Insurance Portability and Accountability Act (HIPAA) and applicable state and local privacy laws	Apply knowledge of privacy laws to protect confidentiality, including Health Insurance Portability and Accountability Act (HIPAA) and applicable state and local privacy laws	Enforce policies that address security, privacy, and legal considerations when communicating epidemiologic information	Develop as-needed policies that address security, privacy, and legal considerations when communicating epidemiologic information
Maintain databases	Define database requirements and manage a database	Ensure management of data from surveillance, investigations, or other sources	Manage data from surveillance, investigations, or other sources

Use analysis plans and analyze data	Create analysis plans and conduct analysis of data	Evaluate analysis of data from an epidemiologic investigation or study	Evaluate data from an epidemiologic investigation or study
Identify key findings from the study	Articulate the need for further investigation or other public health action from literature review and assessment of current data	Evaluate conclusions and interpretations from investigations	Evaluate results of data analysis and interpret conclusions
Assist in evaluation of programs	Assist in the development of measurable and relevant goals and objectives	Ensure evaluation of programs	Evaluate programs
Apply understanding of human and environmental biology and behavioral sciences and principles to determine potential biological mechanisms of disease	Apply understanding of human and environmental biology and behavioral sciences and principles to determine potential biological mechanisms of disease	Ensure the application of understanding of human and environmental biology and behavioral sciences and principles to determine biological mechanisms of disease	Ensure application of understanding of human and environmental biology and behavioral sciences and principles to determine biological mechanisms of disease
Identify the role of laboratory resources in epidemiologic activities	Use laboratory resources to support epidemiologic activities	Ensure the use of laboratory resources to support epidemiologic activities	Develop processes for using laboratory resources to support epidemiologic activities
Prepare written and oral reports and presentations that communicate necessary information to agency staff	Communicate epidemiologic information through giving oral presentations or contributing to the development of written documents to nonprofessional audiences	Ensure preparation of written and oral reports and presentations to professional and nonprofessional audiences and ensure basic principles of risk communication are	Organize preparation of written and oral presentations that communicate necessary information to professional audiences, policymakers, and

		followed	the general public
Use effective communication technologies	Use effective communication technologies	Model interpersonal skills in communication with agency personnel, colleagues, and the public	Model interpersonal skills in communications with agency personnel, colleagues, and the public
Provide epidemiologic input for community planning processes	Provide epidemiologic input for community planning processes	Lead community public health planning processes	Lead community public health planning processes
Practice culturally sensitive epidemiologic activities	Practice culturally sensitive epidemiologic activities	Practice culturally sensitive epidemiologic activities	Practice culturally sensitive epidemiologic activities
Apply appropriate fiscal and administrative guidelines to epidemiology practice	Apply appropriate fiscal and administrative guidelines to epidemiologic practice	Oversee implementation of operational and financial plans	Conduct epidemiologic activities within the financial and operational plan of the agency

Table 3.2. Proportion of competencies representing the Applied Epidemiology Competency (AEC) domains: 2009 Epidemiology Capacity Assessment (ECA) versus the composite study variable

Job Tier:	Entry-level		Mid-level		Senior-level	
AEC Domains	**ECA**	**Study Variable**	**ECA**	**Study Variable**	**ECA**	**Study Variable**
Assessment and analysis	50.0%	56.3%	66.7%	56.3%	29.0%	50%
Basic public health sciences	13.3%	12.5%	10%	12.5%	14.5%	12.5%
Communication	13.3%	12.5%	10%	12.5%	9.7%	18.8%
Community dimensions of practice	3.3%	6.3%	3.3%	6.3%	3.2%	6.3%
Cultural competency	3.3%	6.3%	3.3%	6.3%	3.2%	6.3%
Financial and operational planning and management	3.3%	6.3%	3.3%	6.3%	17.7%	6.3%
Leadership and systems thinking	10%	0%	3.3%	0%	19.4%	0%
Policy development	3.3%	0%	0%	0%	3.2%	0%

Table 3.3 Descriptive statistics for model variables by job tier

Variables	Job Tier							
	All Epidemiologists n=1403		Entry-level n=305		Mid-level n=635		Senior-level n=463	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Competence	3.72	0.68	3.07	.72	3.79	.54	4.07	.53
Epi Training	.58	.49	.33	.47	.59	.49	.75	.43
Years of Experience	.67	.47	.25	.44	.65	.48	.96	.20
Education	.87	.34	.64	.48	.91	.29	.97	.18
Training Opp	3.75	1.64	3.81	1.67	3.79	1.60	3.65	1.67
Avg. Capacity	2.74	1.04	2.55	.87	2.79	1.07	2.79	1.10
No. of Workers	65.2	37.4	65.6	38.21	69.34	37.17	59.25	36.56
Population Size	11.3M	9.9M	10M	8.1M	11.8M	10.2M	11.5M	10.5M
Gov Structure	.66	.47	.68	.47	.67	.47	.63	.48

Table 3.4. Standard multiple regression of workforce and organizational factors on worker competence for all epidemiologists, controlling for state population and governance structure

Variables	Comp (DV)	1	2	3	4	5	6	7	8	9	B	SE	β	p
Constant											3.454	.078		<.0001**
1) Epi Training	.286**										.147	.034	.106	<.0001**
2) Experience	.372**	.113**									.213	.039	.147	<.0001**
3) Education	.301**	.428**	.076**								.216	.052	.106	<.0001**
4) Tier1 v 2	.326**	.162**	.233**	.262**							.488	.036	.559	<.0001**
5) Tier2 v 3	.055*	.077*	.167**	-.006	-.727**						.217	.021	.428	<.0001**
6) Workforce	-.075**	-.011	-.060*	-.091**	-.064*	-.117**					-.001	.001	-.077	.019*
7) Training	-.016	-.030	-.002	-.029	.002	-.034	-.128**				.000	.009	.000	.994
8) Capacity	.001	.096**	.047	.085**	.079**	-.017	.510**	-.005			-.039	.018	-.060	.026*
9) Population	.036	.044	.055*	.035	.072**	-.036	.684**	-.176**	.447**		.000	.000	.067	.033*
Governance	-.027	-.062*	.020	-.087*	.006	-.032	.306**	-.080**	.310**	.292**	.018	.035	.013	.593

MODEL SUMMARY AND ANOVA

R=.571	R^2=.326	Adj R^2=.321	Std Err=.564	F (10,1392)= 67.34**

*p<0.05
**p<0.01

Table 3.5. Standard multiple regression of individual and organizational factors on worker competence for entry-level (Tier 1) epidemiologists, controlling for state population and governance structure

Variables	Comp (DV)	1	2	3	4	5	6	7	B	SE	β	p
Constant									3.112	.168		<.0001**
1) Epi Training	.274**								.369	.097	.240	<.0001**
2) Experience	.032	-.293**							.204	.096	.123	.033*
3) Education	.233**	.479**	-.245**						.250	.095	.166	.009**
4) Workforce	-.066	-.035	.071	.098					.001	.002	.056	.542
5) Training Opp	-.030	-.009	.019	.029	-.041				-.015	.024	-.034	.545
6) Capacity	-.147**	-.004	-.040	.035	.429**	.024			-.140	.051	-.168	.006**
7) Population	-.031	.043	.016	.011	.762**	-.173**	.259**		.000	.000	-.067	.450
Governance	-.019	-.087	.110*	-.154*	.245**	.034	.164**	.281**	.047	.089	.030	.600

MODEL SUMMARY AND ANOVA

R=.365	R^2=.133	Adj R^2=.110	Std Err=.681	F (8,296)= 5.673**

**p*<0.05
***p*<0.01

Table 3.6. Standard multiple regression of individual and organizational factors on worker competence for mid-level (Tier 2) epidemiologists, controlling for state population and governance structure

Variables	Comp (DV)	1	2	3	4	5	6	7	B	SE	β	p
Constant									3.580	.110		<.0001**
1) Epi Training	.109**								.109	.045	.100	.016*
2) Experience	.166**	-.057							.198	.044	.176	<.0001**
3) Education	.056	.335**	-.119**						.079	.079	.042	.316
4) Workforce	-.048	-.011	.048	-.026					-.002	.001	-.130	.028*
5) Training Opp	.025	.007	.047	.001	-.106**				.006	.013	.019	.636
6) Capacity	-.021	.058	.010	.091*	.521**	-.011			-.010	.024	-.019	.692
7) Population	.029	.023	.026	.024	.707**	-.186**	.456**		.000	.000	.123	.030*
Governance	-.024	-.097*	.020	-.070	.342**	-.159**	.317**	.271**	.000	.049	.000	.996

MODEL SUMMARY AND ANOVA

R=.228	R^2=.052	Adj R^2=.049	Std Err=.526	F (8,626)= 4.29**

*p<0.05
**p<0.01

Table 3.7. Standard multiple regression of individual and organizational factors on worker competence for senior management/senior scientist (Tiers 3a and 3b) epidemiologists, controlling for state population and governance structure

Variables	Comp (DV)	1	2	3	4	5	6	7	B	SE	β	p
Constant									3.471	.193		<.0001**
1) Epi Training	.075								.048	.060	.039	.425
2) Experience	.182**	.137*							.453	.121	.174	<.0001**
3) Education	.105*	.288**	.020						.260	.143	.087	.070
4) Workforce	-.083	.071	.037	-.039					-.002	.001	-.112	.090
5) Training Opp	.001	-.062	.044	.003	-.237**				-.006	.015	-.020	.676
6) Capacity	-.056	.135*	.015	.031	.568**	-.005			-.019	.029	-.040	.506
7) Population	-.012	.026	.073	-.002	.636**	-.166**	.502**		.000	.000	.057	.363
Governance	.001	.030	.050	-.011	.295**	-.059	.390**	.333**	.022	.056	.020	.692

MODEL SUMMARY AND ANOVA

R=.233	R^2=.055	Adj R^2=.038	Std Err=.520	F (8,454)= 3.271**

*p<0.05
**p<0.01

Table 3.8. Unstandardized (B) and standardized (β) coefficients and significance values for individual-level and organizational-level variables significantly associated with worker competency score for all regression models

	Individual-level Variables			Organizational-level Variables		
Model	**Epi Training**	**Experience**	**Education**	**Workforce**	**Capacity**	**Population**
All Tiers	B=.147; p<.0001	B=.213; p<.0001	B=.216; p<.0001	β=-.077; p=.019	β=-.039; p=.026	β=.067; p=.033
Entry-level	B=.369; p<.0001	B=.204; p=.033	B=.250; p=.009		β=-.168; p=.006	
Mid-level	B=.109; p=.016	B=.198; p<.0001		β=-.139; p=.028		β=.123; p=.030
Senior-level		B=.453; p<.0001				

CHAPTER IV

Measuring Capacity: An Assessment of Public Health, Environmental, and Agricultural Laboratory Capacity and its Association with Workforce Characteristics

Introduction

Assuring adequate capacity of the public health system to address the health concerns of populations is a challenge that public health officials have struggled with for decades. Deficiencies in public health system capacity at organizational and workforce levels have been theorized to negatively affect sustainability of public health programs and interventions (Hawe, Noort, King, & Jordens, 1997; Schwartz et al., 1993). Strengthening infrastructure has been noted by many as a primary strategy for improving capacity at organizational and system levels (IOM, 1988; Roper, Baker, Dyal, & Nicola, 1992; Baker et al., 2005). As summarized in Chapter II, the public health workforce is a key component of effective public health organizations and the backbone of public health infrastructure (CDC, 2001; Gebbie, Merrill, & Tilson, 2002; Lichtveld, Cioffi, Henderson, Sage, & Steele, 2003; Popovic, 2009; Tilson & Gebbie, 2004). Although findings of public health systems and services research (PHSSR) have shown that organizational factors, including leadership and financial resources, impact performance in achieving objectives related to population health outcomes (Novick, Morrow, & Mays, 2008; Kennedy, 2003; Honore, Simoes, Jones, & Moonesinghe, 2004; Schenck, Miller, & Richards, 1995; Kanarek, Stanley, & Bialek, 2006; Erwin, Greene, Mays, Ricketts, &

Davis, 2011), no published studies address how characteristics of the public health workforce may impact the capacity of public health organizations to deliver public health services.

'Capacity' is a vague term with varied definitions and contexts in the literature (Meissner, Bergner, & Marconi, 1992; Schwartz et al., 1993; Rissel et al., 1995; Crisp, Swerissen & Duckett, 2000, Goodman et al., 1998), making it difficult to measure and operationalize. Organizational capacity has been defined as a "set of attributes that help or enable an organization to fulfill its missions" (Eisinger, 2002), and is the definition adopted for this study. Despite increased interest in measuring capacity in recent years, standardized measurement tools for assessing capacity do not yet exist. As noted by White and colleagues (2005), literature shows common themes that have been theorized to be associated with organizational capacity, including organizational characteristics such as workforce competence, adaptability and durability (Eisinger, 2002); external and human resources (Rowe, Jacobs & Grant, 1999); and proper planning, effective leadership, networks, and specialized skills (Walker and Weinheimer, 1998).

A 2005 study attempted to use these themes to construct survey modules for use in social service agencies serving homeless populations. The modules included: internal characteristics (i.e., type of organization, number of all paid and volunteer staff, operating budget); internal activities (i.e., client intake, staff training, needs assessment); external resources (i.e., collaboration with other agencies); technical assistance; and program activities (i.e., type and frequency of services) (White et al., 2005, p.13). Workforce factors included in the survey instrument addressed number of workers, worker status (i.e., paid or volunteer; full time or part time), educational background, and extent to which staff receive training. The study achieved mixed results with the use of this instrument but provides a basis for considering the many dimensions of organizational capacity.

In public health, few attempts have been made to measure organizational capacity to meet program objectives or deliver Essential Public Health Services (EPHS). As noted in Chapter III, the Council of State and Territorial Epidemiologists last attempted to assess epidemiology program area capacity of state health departments through qualitative measures reported by State Epidemiologists in 2009; however, the workforce and organizational variables used in the study did not significantly predict self-assessed capacity ratings (Boulton, Hadler, Beck, Ferland, & Lichtveld, 2011). The secondary data analysis completed in Chapter III found low significant bivariate correlation between EPHS capacity scores and epidemiology training, education, and job tier of the workers, as well as moderate significant correlation with organizational factors including workforce size, population size, and governance structure of the health department. The conflicting results may suggest that different measures of organizational capacity yield different associations with workforce and organizational variables.

Public Health, Environmental and Agricultural Laboratories

In 2011, the Association of Public Health Laboratories (APHL) and the University of Michigan Center of Excellence in Public Health Workforce Studies (UM CEPHS) conducted the National Laboratory Capacity Assessment to collect organizational and workforce data, which included a survey of directors of U.S. public health, environmental, and agricultural laboratories (PHEALs). PHEALs are an essential component of the public health system often located in local, state, and federal government agencies. Public health laboratories are often affiliated with health departments, while environmental and agricultural laboratories may exist outside the health department but are considered part of the public health system and work closely with health departments. PHEALs are an interesting unit within the public health system to examine because of the specificity of their work, which tends to be similar in function regardless of the type or setting of the laboratory. For example, laboratories may vary in the number and type of tests they perform; however, the equipment and basic skills needed by the workforce to perform the tests are likely to be similar. PHEALs share characteristics of other public health department units in that their work is guided by the EPHS. However, they have unique characteristics related to their workforce and organizational structure.

Laboratory workers are classified into 8 different job categories, 6 of which are scientific and/or administrative. The remaining two categories, laboratory aide/assistant and laboratory technician, comprise 16% of the PHEAL workforce. These workers are primarily educated at the high school/associate's degree level: 77% of aides/assistants are hold high school diplomas or associate's degrees, as do 60% of technicians. The largest classification of laboratorians is entry-level scientists, who comprise 59% of the PHEAL workforce and typically hold a degree in laboratory science or medical technology (UM CEPHS/APHL, 2012). This workforce profile can be contrasted with the epidemiology workforce examined in Chapter III's study, which was comprised of workers who were relatively highly educated. Sixty-four percent of entry-level epidemiologists held graduate degrees, for example. Although more epidemiologists may hold graduate degrees upon beginning their job, laboratorians who are scientists or administrators tend to hold more field-related degrees. Degrees in a laboratory science are expected of laboratorians; in contrast, only one-third of entry-level epidemiologists were reported to hold an epidemiology degree in Chapter III's analysis.

The purpose of this paper is to determine whether size and composition of the PHEAL workforce and organizational policies related to hiring and workforce development are significantly associated with organizational capacity. Secondarily, this study will examine two different measures of organizational capacity to determine whether similar associations with workforce and organizational factors are produced. First, I examined associations between reported capacity levels and the following laboratory characteristics: organizational policies including types of continuing education and professional development opportunities offered to staff and the minimum number of years of laboratory experience required of workers to be hired in a PHEAL; and workforce factors including number of laboratory workers, the proportion of workers in each laboratory who function as scientists, proportion of workers holding a bachelor's or graduate degree, and number of degrees in a public health or laboratory-science discipline obtained by PHEAL workers, most of which are measures shown in Chapter III to be associated with worker competence. The quality of equipment and instrumentation used by the laboratory is included as a control variable, given its potential impact on whether a laboratory can adequately carry out its activities and services.

Methods

APHL and UM CEPHS jointly developed the National Laboratory Capacity Assessment to assess the size, composition, and characteristics of the workforce in PHEALs, as well as capacity measures rated by the Laboratory Director. A second survey was developed and administered to individual laboratory workers; however, this study uses variables collected at the organizational level only. The survey was piloted in 2011 with 4 laboratory directors in North Dakota, New Mexico, Michigan, and Vermont. APHL and UM CEPHS staff performed cognitive interviews with all pilot testers to obtain feedback on survey design. Recommendations from pilot testers were used to revise the survey instrument. APHL developed the online survey questionnaire using *mrInterview* platform and distributed it to 105 PHEAL directors in all 50 states, the District of Columbia (D.C.), and Puerto Rico, including 50 state public health laboratories, 41 local public health laboratories, 8 environmental laboratories, and 6 agricultural laboratories, all of which were members of APHL. Data collection took place from July through September 2011. APHL staff followed up with laboratory directors by email and phone throughout the organizational-level data collection period to encourage additional responses (UM CEPHS/APHL, 2012).

Measures

The following measures were used in the models analyzed in this secondary data analysis.

Capacity. Two measures of capacity were used as dependent variables. The first model uses Overall Capacity, a summary rating of the laboratory's capacity to perform necessary activities and services in all program areas. Laboratory Directors used a 6-point rating scale of: None (0% capacity to perform); Minimal Capacity (1%-24% capacity to perform); Partial Capacity (25%-49% capacity to perform); Substantial Capacity (50%-70% capacity to perform; Almost Full Capacity (75%-99% capacity to perform); and Full Capacity (100% capacity to perform). Although collected as an ordinal categorical variable, the analysis considers this variable to be continuous due to its consistent intervals and underlying scale ranging from 0%-100%.

The second capacity variable, Averaged Program Capacity, uses the same 6-point response scale to assess capacity in the following 19 laboratory program areas: agricultural chemistry, agricultural microbiology, bacteriology, clinical chemistry/hematology, education and training, emergency preparedness and response, environmental microbiology, laboratory administration/operation, laboratory quality assurance and/or continuing quality improvement, laboratory regulation and inspection, laboratory safety and/or security, molecular biology, mycology, newborn screening, parasitology, serology/immunology, toxicology, and virology. Laboratories were also given the option to identify program areas that were not applicable, which were removed from the laboratory's average capacity score.

Number of Workers. This continuous variable is a summation of full-time equivalent (FTE) workers in each of the 19 laboratory program areas.

Scientists. This variable represents the proportion of workers classified in one of the following positions: Laboratory Scientist, Laboratory Scientist-Supervisor, Laboratory Scientist-Manager, and Laboratory Developmental Scientist. Full descriptions of these job classifications have been reported by APHL and UM CEPHS

(UM CEPHS/APHL, 2012). The denominator used for all proportional variables reflects the total number of workers reported by job classification and degree, which varies slightly from the total FTEs reported for the Number of Workers variable.

Education. This variable was computed by adding the proportion of workers with a bachelor's degree to the proportion of workers with a graduate degree (i.e., master's, doctoral, or professional degree such as MD, DVM) in any field of study.

Lab Degree. The Lab Degree variable represents the number of bachelor's, master's and/or doctoral degrees in public health or a laboratory science-related field such as biology, zoology, molecular biology, microbiology, biochemistry, genetics, analytical chemistry, or medical technology/medical laboratory science obtained by laboratory workers, which could include more than one degree per worker.

Minimum Required Experience. This variable represents the minimum number of years of laboratory experience the PHEAL requires for entry-level laboratory scientists, where 0= none; 1= less than 1 year; 2= 1-2 years; and 3= more than 2 years.

Training. The training variable is a composite summation of responses to questions related to continuing education and professional development opportunities offered by the PHEAL. Positive responses to the dichotomous variables received a score of 1 and were summed to create the composite, which ranged from 0 to 8. PHEAL Directors reported whether their laboratory offered the following provisions to support continuing education/professional development: financial support for courses; internal training opportunities; training for local public health laboratory or clinical laboratory partners; reimbursement for dues or memberships to professional societies; support staff positions responsible for monitoring, developing, or providing internal training; time away from job to attend classes; time off to attend external trainings or participate in distance learning trainings; and tuition reimbursement.

Equipment Quality. Used as a continuous control variable, Laboratory Directors rated the quality of the instrumentation and equipment in their laboratory on a 5-point Likert scale of Very Poor, Poor, Fair, Good, and Very Good.

Statistical Procedures and Analysis

Descriptive analyses and assumption tests were performed using SPSS version 19. Results were tabulated in aggregate for all responses from workers from the 50 states, D.C., and Puerto Rico. To ensure all variables reflected an approximately normal distribution, log transformations were completed for Number of Workers and Lab Degree, which exhibited substantial positive skewness. Nine scores were dropped for the Lab Degree variable for being outliers; mean substitution was used to ensure the cases were not removed during the analysis by listwise deletion. Next, Pearson Product Moment correlations were calculated for all variables to identify significant relationships between outcome and predictor variables and to check for multicollinearity and singularity and regression models were run using data from the 80 PHEALs. The sample size was sufficient to achieve power greater than 0.8 for standard multiple regression analyses (power=0.97, α=0.05) (Soper, 2012). Finally, the 19 program area capacity variables were factor analyzed with Varimax rotation using SPSS FACTOR. Three factors were formed using a 0.60 factor loading cutoff point. Responses for each factor were averaged to calculate a composite factor capacity score and regression models were run using each factor as the dependent variable. The University of

Michigan Institutional Review Board (IRB) reviewed the study design and materials and ruled it exempt from ongoing IRB review.

Results

Descriptive Statistics

Descriptive statistics were examined for all variables. Histograms of all variables showed approximately normal distribution after log transformations were performed on Lab Degree and Number of Workers variables. Means and standard deviations (SD) for the dependent variables of Averaged Program Capacity and Overall Capacity differed, with Laboratory Directors reporting a mean score of 4.15 for program capacity and 5.36 for overall capacity (SD= .95 and .72, respectively). PHEALs employed an average of 69.5 laboratorians (SD=90.1). Approximately 85.9% of the workforce has obtained either a bachelors or graduate degree as their highest degree (SD=13.8). An average of 60.7 workers per laboratory hold a degree in a laboratory science or public health-related field (SD=66.0), with several likely holding more than one degree such as a bachelor's and master's degree in a laboratory science or public health field. On average, PHEALs require less than one year of job experience for entry-level scientist positions (mean=.99; SD=1.0). Approximately 76.6% of the workforce is employed in a scientist classification (SD=13.4). For continuing education and professional development, PHEALs provide an average of 5.6 of the 8 provisions surveyed (SD=1.6). Overall, Laboratory Directors rated the quality of their laboratory equipment and instrumentation between "fair" and "good" (mean=3.54; SD=.59) (Table 4.1).

Overall PHEAL Capacity

In the first model, which used Overall Capacity as the outcome of interest, there was low to moderate significant correlation between the dependent variable and the log-transformed variable of Number of Workers (r=.24), Education (r= -.26), Experience (r=-.24), and Equipment Quality (r= -.32). Several predictor variables were also significantly correlated with each other, including Number of Workers with proportion of scientists (r=.49), Training (r=.27); and the log-transformed Lab Degree variable (r=.78). Strong correlations were observed between the proportion of scientists in the workforce and the proportion of the workforce trained at the bachelor's or graduate degree level (r=.24) as well as Lab Degree (r=.54) (Table 4.2).

A standard multiple regression was performed with Overall Capacity as the dependent variable and the log of Number of Workers, proportion of scientists in the PHEAL workforce, proportion of workers educated at the bachelors or graduate degree level, minimum years of experience required for an entry-level scientist position, and extent to which the PHEAL supports continuing education and professional development opportunities for staff as independent variables; quality of the laboratory's equipment and instrumentation was included as a control variable. R was significantly different from zero, F (7, 72)= 4.603, p<.01, with R^2 of .309. The adjusted R^2 value of .242 indicates that 24.2% of the variability in overall PHEAL capacity is predicted by the independent variables. Four regression coefficients were significantly different from zero: the log-transformed Number of Workers variable (p=.023), Education (p=.039), and Training (p=.031) at the p= 0.05 level; and quality of laboratory equipment at the p= 0.01 level (p=.002) (Table 4.3). Based on their squared semi-partial correlations, .245 of the R^2 was attributable to unique sources; the remaining .064 represents variance that the four significant variables jointly contributed to R^2.

Both standardized and unstandardized coefficients are shown in Table 4.3. The standardized beta weights showed that 1 percent change in the number of workers employed by the laboratory is associated with a .003 change in capacity. A 1 SD increase in the number of training opportunities offered to staff resulted a .227 increase in capacity scores. Two variables were significantly negatively associated with Overall Capacity: a 1 SD increase in the proportion of the workforce that is college-educated and in the equipment quality score resulted in .222 and .331 decreases in capacity, respectively. To further analyze these results, two-way interaction variables of education and equipment; education and training; and training and equipment were created by centering the variables and multiplying their values. The interaction terms were not significant in any model so were removed and the original models were maintained. The proportion of scientists in the workforce, having workers with a laboratory science-related degree, and requiring job experience were not significant in this model. Casewise diagnostics and residual statistics tables showed no evidence of multivariate outliers, as the maximum Mahalanobis distance is less than the critical χ^2 value at α=.001 for 7 degrees of freedom. Collinearity statistics show tolerance and VIF values to be sufficient, as tolerance was above zero and VIF was near or below 2 for all variables. Eigenvalues were above zero for several of the model dimensions and the condition index is less than 15 for several all model dimensions, supporting the notion that collinearity was not likely a serious problem in this data set (data not shown).

Averaged PHEAL Program Capacity

Similar to the Overall Capacity variable, Pearson Product Moment correlations showed that Averaged Program Capacity was significantly correlated with the log-transformed Number of Workers variable (r=.28), Education (r=-.24), and Training (r=.29). A second multiple regression was performed with Averaged Program Capacity using the same predictor and control variables as the first model. R was significantly different from zero, $F (7, 72)= 3.502$, $p<.01$, with R^2 of .254. The adjusted R^2 value of .181 indicates that 18.1% of the variability in overall PHEAL capacity is predicted by the independent variables. Three of the seven regression coefficients were significantly different from zero at the p= 0.05 level in this model: the proportion of workers educated at the bachelors or graduate degree level (p=.023), providing training opportunities to staff (p=.018), and quality of laboratory equipment (p=.021) (Table 4.3). The log-transformed Number of Workers variable approached significance (p=.076). The proportion of scientists in the workforce, having a degree in laboratory science, and requiring prior job experience were not significant in this model. Based on their squared semi-partial correlations, .174 of the R^2 was attributable to unique sources; the remaining .080 represents variance that the six significant variables jointly contributed to R^2.

Standardized beta weights showed that 1 SD increase in training opportunities for staff contributes to a .260 increase in capacity, while 1 SD increase in proportion of college-educated workers and quality of equipment resulted in .255 and .246 decreases in capacity, respectively. Casewise diagnostics and residual statistics tables showed no evidence of multivariate outliers. Similar to the first model, the maximum Mahalanobis distance is less than the critical χ^2 value at α=.001 for 7 degrees of freedom. Tolerance, VIF statistics and eigenvalues were within acceptable values (data not shown).

To analyze the program area capacity variable further, factor analysis identified three latent factors on which to group the 19 program areas. Factor 1 appears to represent program areas with large numbers of staff proportionally, as well as administrative areas, and includes: bacteriology, emergency preparedness, environmental microbiology, environmental chemistry, laboratory administration/operation, laboratory quality assurance, laboratory safety/security, molecular biology, parasitology, serology/immunology, and virology. Factor 2 groups program areas with much smaller numbers of staff and program areas that were identified as "not applicable" by many PHEALs. Factor 2 includes: agricultural chemistry, agricultural microbiology, clinical chemistry/hematology, mycology, newborn screening, and toxicology. Factor 3 represents the education and training program area.

Regression models run for each factor showed the Factor 1 model R was significantly different from zero, $F(7, 72)= 3.87$, $p=.001$, with R^2 of .273. The adjusted R^2 value of .203 indicates that 20.3% of the variability in Factor 1 capacity is predicted by the independent variables. The log-transformed Number of Workers variable ($\beta=.359$; $p=.021$), the proportion of workers educated at the bachelors or graduate degree level ($\beta= -.264$; $p=.017$), providing training opportunities to staff ($\beta=.249$; $p=.022$), and quality of laboratory equipment ($\beta=-.252$; $p=.017$) were significant variables in this model. The Factor 2 model was not significant. The Factor 3 model's R was significantly different from zero, $F(7, 72)= 5.103$, $p<.0001$, with R^2 of .332. Approximately 26.7% of the variability in Factor 3 capacity is predicted by the independent variables, according to the adjusted R^2 value. Providing training opportunities to staff (β=.478; p<.0001), and quality of laboratory equipment (β=-.271; p=.008) were significant variables in this model.

Discussion

The findings of this study provide some empirical support to the hypothesis that workforce factors can influence the capacity of laboratories to deliver public health services. Across both models, the proportion of workers with a bachelor's or graduate degree, the extent to which continuing education and professional development opportunities are offered to staff, and the quality of the laboratory's equipment and instrumentation were significantly associated with laboratory capacity. Surprisingly, education and equipment quality were negatively associated, in that the higher the proportion of college-educated workers a PHEAL employed, the lower the capacity score. A similar relationship was found for equipment quality. These associations were found in the two significant factor-based models, as well.

Based on the results of Chapter III, one would expect a highly educated workforce to result in workers of higher competence level, who would, in turn, contribute to higher capacity of the organization to deliver EPHS. However, the workforce profile of PHEALs differs from the state health department epidemiology workforce. As mentioned previously, laboratory aides/technicians make up 16% of the PHEAL workforce and are largely trained at the associate's degree and high school or equivalent level. Their job tasks include processing specimens/samples, performing moderate to high complexity testing, and reporting test results (UM CEPHS/APHL, 2012). The negative association between having a workforce that is college educated and laboratory capacity may imply that the laboratory aides/technicians, although a small piece of the workforce, have a substantial role in the delivery of EPHS by virtue of their job tasks.

It is also possible that capacity relies more heavily on training than education. Laboratory tasks tend to be more procedurally-oriented in comparison to tasks performed by epidemiologists, for example, which may rely on more critical thinking and analytic skills. Laboratory tasks are complex, but repetitive, fixed and procedurally rigid in how they are executed, perhaps making on-the-job training a more effective way to improve laboratory capacity than degree attainment. There is some evidence that on-the-job training is often utilized by PHEALs to enhance the skills of scientific staff. For example, APHL and the Centers for Disease Control and Prevention developed the National Laboratory Training Network (NLTN) in 1989 to conduct training needs assessments and provide workshops and training to laboratorians. Over 4,000 workshops have trained over 220,000 clinical and public health laboratorians since the inception of the NLTN (APHL, 2012), providing PHEALs with a centralized system from which to access laboratory training on a variety of topics. Additionally, the 2011 National Laboratory Capacity Assessment found that approximately half of the PHEAL workforce held laboratory licensure and/or certification, which require periodic continuing education to be completed (UM CEPHS/APHL, 2012). The mandate for a substantial proportion of the laboratory workforce to participate in trainings to maintain licensure and certification, coupled with the presence of a national network to provide uniform trainings to all PHEALs, may lend credence to the idea that standardized on-the-job trainings are a feasible way to improve worker performance and that sustained investments in programs like the NLTN may positively impact laboratory capacity.

The negative association between laboratory equipment and both measures of organizational capacity may reflect the difficulty PHEAL directors may have had comprehensively assessing hundreds of individual pieces of equipment, whose quality may have varying impact on capacity. For example, a low quality equipment item with limited utility may have a lesser impact on laboratory capacity than a low quality equipment item in constant use. This summative measure of equipment quality does not allow for these differences to be examined. The lack of significant interaction effects between equipment, training, and education eliminates the possibility of education or training affecting the relationship between equipment quality and laboratory capacity in this study.

The finding that higher laboratory capacity is associated with PHEALs that provide more workforce development opportunities through support of continuing education, tuition reimbursement, and other professional development options is a positive one. As noted in Chapter III, national efforts to better train the public health workforce have increased over the past decade. Although no studies directly show that worker training results in improved organizational capacity or performance, the findings of this study provide empirical support to laboratory policies that offer a range of professional development opportunities, and may encourage administrators to expand continuing education options for laboratory staff.

The results of the Overall Capacity regression model showed a positive association between number of full-time equivalent workers employed by the PHEAL and capacity, indicating that the size of the workforce impacts ability to deliver services, although the regression coefficient is small. Additional research is needed to determine what types of workers best contribute to organizational capacity. The Experience variable used in this study looked only at the PHEAL policies for requiring previous laboratory experience. A better measure of experience to be considered in future research would be the average number of years of experience laboratory workers have in each PHEAL.

In terms of capacity measurement, the findings show differences in strength of association between the two capacity variables and the predictor variables. The summative measure Overall Capacity exhibited a better model fit, as evidenced by higher R^2 value and F score compared to the composite Averaged Program Capacity R^2 value. One explanation for this finding may be that respondents considered more than program capacity when rating the overall ability of their laboratories to perform necessary services. For example, all administrative, managerial, or technical work performed by the laboratories may not be adequately captured in the Averaged Program Capacity variable. The Averaged Capacity model produced some significant associations, which is an improvement from the program capacity results in the 2009 CSTE study (Boulton et al., 2011). This may be a result of differences in how program capacity was measured in the two studies, having more variables to test in the APHL data set compared to the CSTE data set, or may imply that this measure works slightly better in a laboratory setting where program area tasks may be more standardized than in a state health department Bureau of Epidemiology, for example. Although these findings are specific to these predictor and outcome variables, future surveys may find it beneficial to continue to include a program area capacity assessment for the purpose of monitoring change over time, as well as a summative measure of capacity, which may provide a slightly better estimate of the organization's ability to deliver services.

There are several study limitations to consider. First, the National Laboratory Capacity Assessment did not achieve a 100% response rate. It is possible that non-responding laboratories were significantly different from responding laboratories in terms of workforce factors and capacity scores. Second, as noted in Chapter III, self-rated subjective measures such as those used to measure capacity can be limited by bias. It is unknown whether the designated official from each PHEAL who completed the survey interpreted "capacity" in the same way, due to the abstractness of the term itself, although the use of a quantitative scale (i.e., 0% to 100% capacity) was intended to provide some consistency to how this measure was interpreted by respondents. Third, previous studies have theorized numerous factors, primarily organizational characteristics, which may be related to organizational capacity. These characteristics are not tested in these models due to lack of data. Therefore, it is possible that control variables are not included in this model that could alter the findings of the study. Finally, caution should be taken when generalizing these study findings to non-laboratory settings.

Conclusion

This is the first analysis to attempt to identify workforce factors that predict organizational capacity. Although the findings are mixed, they do provide some guidance on how to structure future studies. First, the workforce size, particularly the number of laboratory aides/technicians, seems to be an important component of laboratory capacity, as does provision of training and professional development activities.

Overall, the study validates some of the previous epidemiology capacity study findings (Boulton, Lemmings & Beck, 2009) and suggests that current measures to estimate program and organizational capacity are challenging to use in statistical analyses and, at times, produce seemingly counterintuitive results. Use of a subjective summary measure may be far too simplistic to adequately estimate an organization's capacity. As noted previously, studies in other fields have identified several factors that may potentially contribute to organizational capacity. No scale has been constructed that has received consensus endorsement; however, it would be beneficial to begin to test these measures in public health organizational settings. Future research devoted to constructing a scale that incorporates elements of organizational and workforce characteristics, workforce development activities, program activities, and partnerships and networks, and testing its usability in public health organizations would be of considerable value.

The use of new methods of analysis could be useful in trying to develop a measure of organizational capacity. For example, "capacity" could be considered to be a latent variable, in that it is not directly observable but could be inferred through mathematical modeling such as structural equation modeling (Kline, 2005). This analysis technique requires a substantially larger sample size than is feasible when surveying state-level organizations; however, a study of local health departments, of which over 2,500 exist, could provide an ideal study population.

Overall, the techniques used to measure capacity and the workforce factors that may contribute to capacity must be improved in order to produce consistent findings across public health organizational data sets. The field lacks a systematic method for collecting detailed workforce and organizational-level data on an ongoing basis, which adds to the research challenges. Improving measures and data collection methods is a critical next step to identifying associations between workforce characteristics and organizational capacity that could aide public health organizations in strengthening their ability to deliver services and improve population health.

Chapter IV Literature Cited

Association of Public Health Laboratories. (2012). *National laboratory training network,* http://www.aphl.org/member/training/Pages/nltn.aspx.

Baker, E.L., Potter, M.A., Jones, D.L., Mercer, S.L., Cioffi, J.P., Green, L.W., … Fleming, D.W. (2005). Public health infrastructure and our nation's health. *Annual Review of Public Health, 26,* 303-318. doi: 0.1146/annurev.publhealth.26.021304.144647

Boulton, M.L., Lemmings, J., & Beck, A.J. (2009). Assessment of epidemiology capacity in state health departments, 2001-2006. *Journal of Public Health Management and Practice, 15,* 328-336.

Boulton, M.L., Hadler, J., Beck, A.J. Ferland, L., & Lichtveld M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Reports, 126*, 84-93.

Centers for Disease Control and Prevention. (2001). *Public health's infrastructure: a status report.* Atlanta, GA: CDC.

Crisp, B.R., Swerissen, H., & Duckett, S.J. (2000). Four approaches to capacity building in health: Consequences for measurement and accountability. *Health Promotion International*, *15,* 99-107. doi: 10.1.1.120.8908

Eisinger, P. (2002). Organizational capacity and organizational effectiveness among street level food assistance programs. *Nonprofit and Voluntary Sector Quarterly, 31,* 115-130.

Erwin, P.C., Greene S.B., Mays G.P., Ricketts T.C., & Davis M.V. (2011). The association of changes in local health department resources with changes in state-level health outcomes. *American Journal of Public Health*, *101,* 609-615. doi: 10.2105/AJPH.2009.177451

Gebbie, K.M., Merrill, J., & Tilson, H.H. (2002). The public health workforce. *Health Affairs, 21,* 57-67.

Goodman, R.M., Speers, M.A., McLeroy, K., Fawcett, S., Kegler, M., Parker, E., …Wallerstein, N. (1998). Identifying and defining the dimensions of community capacity to provide a basis for measurement. *Health Education & Behavior, 25,* 258-278. doi: 10.1177/109019819802500303

Hawe, P., Noort, M., King, L., & Jordens, C. (1997). Multiplying health gains: The critical role of capacity building within health promotion programs. *Health Policy, 39,* 29-42.

Honore, P.A., Simoes, E.J., Jones, W.J., & Moonesinghe, R. (2004). Practices in public health finance: An investigation of jurisdiction funding patterns and performance. *Journal of Public Health Management and Practice, 10,* 444-450.

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

Kanarek, N., Stanley, J., & Bialek, R. (2006). Local public health agency performance and community health status. *Journal of Public Health Management and Practice, 12,* 522-527.

Kennedy, V.C. (2003). A study of local public health system performance in Texas. *Journal of Public Health Management and Practice, 9,* 183-187.

Kline, R. (2005). *Principles and practice of structural equation modeling.* (2nd ed.) New York: Guilford Press.
Lichtveld, M.Y., Cioffi, J., Henderson, J., Sage, M., & Steele, L. (2003). Editorial. People protected – public health prepared through a competent workforce. *Journal of Public Health Management and Practice, 9,* 340-343.
Meissner, H.I., Bergner, L., & Marconi, K.M. (1992). Developing cancer control capacity in state and local public health agencies. *Public Health Reports, 107,* 15-23.
Novick, L.F., Morrow, C.B., & Mays, G.P. (Eds.) (2008). *Public health administration: Principles for population-based management* (2nd ed.). Sudbury, MA: Jones and Bartlett.
Popovic, T. (2009). Workforce science: a critical component to ensuring future of health. *Journal of Public Health Management and Practice, 15,* S3-S4.
Rissel, C., Finnegan, J., & Bracht, N. (1995). Evaluating quality and sustainability: Issues and insights from the Minnesota Heart Health Program. *Health Promotion International, 10,* 199-207.
Roper, W.L., Baker, E.L., Dyal, W., & Nicola, R.M. (1992). Strengthening the public health system. *Public Health Reports, 107,* 609-615.
Rowe, W.E., Jacobs, N.F., & Grant, H. (1999). Facilitating development of organizational productive capacity: a role for empowerment evaluation. *Canadian Journal of Program Evaluation,* special issue, 69-92.
Schenck, S.E., Miller, C.A., & Richards, T.B. (1995). Public health performance related to selected health status and risk measures. *American Journal of Preventive Medicine, 11,* 55-57.
Schwartz, R., Smith, C., Speers, M.A., Dusenbury, L.J., Bright, F., Hedlund, S., …Schmid, T.L. (1993). Capacity building and resource needs of state health agencies to implement community-based cardiovascular disease programs. *Journal of Public Health Policy, 14,* 480-493. Retrieved from: http://www.jstor.org/stable/3342879.
Soper, D.S. (2012). *Post-hoc statistical power calculator for multiple regression* (Online Software), http://www.danielsoper.com/statcalc3.
Tilson, H. & Gebbie, K.M. (2004). The public health workforce. *Annual Review of Public Health*, *25,* 341-356.
University of Michigan Center of Excellence in Public Health Workforce Studies/Association of Public Health Laboratories. (2012). *2011 national laboratory capacity assessment.* Ann Arbor, MI: University of Michigan.
Walker, C. & Weinhimer, M. (1998). *Community development in the 1990s.* Washington, DC: Urban Institute.
White, M.D., Fisher, C., Hadfield, K., Saunders, J., & Williams, L. (2005). Measuring organizational capacity among agencies serving the poor: implications for achieving organizational effectiveness. *Justice Policy Journal, 2,* 1-39. Retrieved from: www.cjcj.org/files/measuring_organizational.pdf.

Table 4.1. Descriptive statistics for study variables

Variable	N	Minimum	Maximum	Mean	Std Dev
Overall Capacity	80	3	6	5.36	.716
Averaged Program Capacity	80	2.05	6.00	4.15	.946
Number of Workers	80	4	635	69.51	90.077
Scientists (%)	80	33	98	76.61	13.439
Education (%)	80	9	100	85.86	13.820
Lab Degree	71	3	348	60.66	65.993
Experience	80	0	3	.99	1.025
Training	80	1	8	5.58	1.636
Equipment Quality	80	3	5	3.54	.594

Table 4.2. Correlation matrix of study variables

	Overall Capacity	Average Capacity	Workers	Scientists	Education	Lab Degree	Experience	Training
Overall Capacity	1.0							
Averaged Program Capacity	.619**	1.0						
Number of Workers (log)	.243*	.275*	1.0					
Scientists (%)	.019	.042	.492**	1.0				
Education (%)	-.260*	-.235*	.068	.241*	1.0			
Lab Degree (log)	.062	.167	.783**	.538**	.227	1.0		
Experience	-.235*	-.076	-.135	-.075	.205	-.028	1.0	
Training	.220	.293**	.273*	.152	.033	.292*	.065	1.0
Equipment Quality	-.315**	-.203	.046	.041	-.005	.011	.177	.095

*p<.05
**p<.01

Table 4.3. Regression weights and model summary statistics for Overall Capacity and Averaged Program Capacity models

Variables	**Model 1: Overall Capacity**				**Model 2: Averaged Program Capacity**			
	B	SE	β	p	B	SE	β	p
Constant	7.078	.692		.000**	5.633	.950		.000**
Number of Workers (log)	.508	.218	.344	.023*	.540	.300	.277	.076
Scientists (%)	-.002	.006	-.031	.797	-.003	.009	-.047	.703
Education (%)	-.011	.005	-.222	.039*	-.017	.008	-.255	.023*
Lab Degree (log)	-.307	.250	-.184	.223	-.049	.343	-.022	.887
Experience	-.074	.073	-.106	.311	.034	.100	.036	.738
Training	.099	.045	.227	.031*	.151	.062	.260	.018*
Equipment Quality	-.399	.121	-.331	.002**	-.391	.166	-.246	.021*
Model Summary	R=.556	R^2=.309		Adj R^2=.242	R=.504	R^2=.254		Adj R^2=.181
	Std Err=.623			F(7,72)=4.603**	Std Err=.856			F(7,72)=3.502**

*p<.05
**p<.01

CHAPTER V

Conclusions

This dissertation adds to the growing evidence base in public health systems and services research (PHSSR) of associations between workforce and organizational characteristics. The systematic review of public health workforce literature in four key research areas summarizes results of workforce studies. Secondary data analysis of two national surveys- the 2009 Epidemiology Capacity Assessment (ECA) conducted by the Council of State and Territorial Epidemiologists and the University of Michigan Center of Excellence in Public Health Workforce Studies/Association of Public Health Laboratories 2011 National Laboratory Capacity Assessment- provide a foundation on which to base future research.

Summary of Findings and Implications for Public Health Practice

The systematic review of public health workforce literature identified 157 peer-reviewed articles and gray literature documents that detail the scope of the nation's recommended public health workforce research agenda and studies that attempt to address key research questions. The review uncovered few empirical studies relative to the number of commentaries, reports, and descriptive pieces; thus research questions related to size and composition of the workforce, workforce effectiveness and impact on population health; forecasting workforce demand; and workforce development policies could not be definitively answered. Despite that, the review highlighted promising work moving the field toward quantitative studies, such as the work by Boulton et al. (2009, 2011) in characterizing the size, composition, and capacity of the state health department epidemiology workforce, and of Erwin et al. (2011), who found significant associations between increased staffing in health departments and decreases in cardiovascular disease mortality over time.

The conclusion of the systematic review paper is a call to action for PHSSR researchers. Numerous articles recommend the use of natural experiments and other study designs to support quantitative analyses using workforce variables though few studies appear in the literature. The infusion of PHSSR funding from federal sources, such as the Centers for Disease Control and Prevention and Health Resources and Services Administration, and the Robert Wood Johnson Foundation should allow for new studies to be undertaken. The workforce research agendas published over the past decade (Cioffi, Lichtveld, & Tilson, 2004; Crawford, Summerfelt, Roy, Chen, Meltzer, & Thacker, 2009; Consortium, 2012) provide clear guidance on where to target future research efforts to add the quantitative evidence that is greatly needed in literature.

The second dissertation paper examined associations between worker competence and characteristics of epidemiologists in state health departments such as education, formal training in epidemiology, years of experience as an epidemiologist. The study also considered organizational characteristics, including essential public health service capacity as assessed by the State Epidemiologist, extent to which training opportunities are offered to staff, and size of the workforce. Although the organizational characteristics did not generally predict worker competence significantly, significant associations between competence and individual worker characteristics were present and varied by epidemiologist job tier (i.e., entry-level, mid-level, or senior-level). Level of epidemiology training exhibited the strongest association with worker competence for entry-level epidemiologists, while experience was the most predictive of competence in mid-level and senior-level epidemiologists.

The findings of this study can be useful for public health practice by providing a preliminary profile of how a state health department epidemiology bureau may want to structure its workforce, focusing on different types of worker characteristics by job tier to maximize worker competence. Additionally, a further look at competency scores could inform both public health administrators and academic institutions about what types of knowledge, skills and abilities should be developed in workers either through their academic coursework or continuing education and professional development efforts.

The final dissertation paper examines organizational characteristics of U.S. public health, agricultural and environmental laboratories, including policies related to workforce hiring, development, and composition, and analyzes them in two models to identify associations with laboratory capacity. The study found that use of a summative measure of overall capacity resulted in a model that exhibited stronger associations with organizational characteristics such as number of full-time equivalent workers employed by the laboratory, the proportion of workers educated at the bachelor's level or above, and the extent to which training opportunities are provided to staff, as compared to a model using a composite average score of capacity in 19 laboratory program areas.

The results of this study provide two important findings for PHSSR and public health practice. First, as researchers, we must push ourselves to develop new metrics for workforce and organizational capacity (Boulton, 2009). The measures used in both Chapter III and Chapter IV dissertation papers were slightly different but showed the same vulnerability in analysis by producing counterintuitive results at times. Efforts should be made to develop and test a capacity scale for public health organizations. Second, a preliminary look at this study's results shows that Laboratory Directors may want to expand the number, type, and quality of training and professional development opportunities provided to staff. The results support the hypothesis that more staff, particularly those functioning as laboratory aides/technicians, may result in higher capacity; however, this study was unable to identify how the workforce should be composed and structured to maximize efficiency and organizational capacity.

Although Chapter III and Chapter IV summarize similar studies conducted on different segments of the workforce, some of the findings differ. For example, offering training opportunities to staff was not a significant predictor of workforce competence of epidemiologists in Chapter III's study, but was a significant predictor of laboratory capacity in Chapter IV's study. Interestingly, negative correlations also existed between capacity and training opportunities in the ECA data set used in Chapter III, although these were not significant relationships. One possible explanation for the contrasting findings could be that training of laboratory workers may be more structured and consistent, as their jobs are likely to be more narrowly defined in comparison to epidemiologists, which allows for applied training that improves laboratory service delivery. Another consideration may be that the survey instruments collected different information about training opportunities; the ECA measure reflected a summation of 6 questions, while the National Laboratory Capacity Assessment measure was a composite of 8 questions. Perhaps the measure that includes more extensive information better predicts the outcome variable.

Findings of Chapter III highlighted the importance of education and experience of in improving competence of epidemiologists; however, these characteristics aggregated to the organizational level in Chapter IV did not appear to significantly improve laboratory capacity to perform necessary activities and services. The studies were unable to test a direct link at an organizational level between competence of the workforce and capacity of the organization, although the importance of a competent workforce has been highlighted in public health literature (Cioffi, et al., 2004). It is possible that the importance of individual worker characteristics differ between laboratories and epidemiology bureaus. Perhaps laboratories function better when workers exhibit characteristics such as high motivation to complete work and job satisfaction, which were unable to be tested due to lack of data.

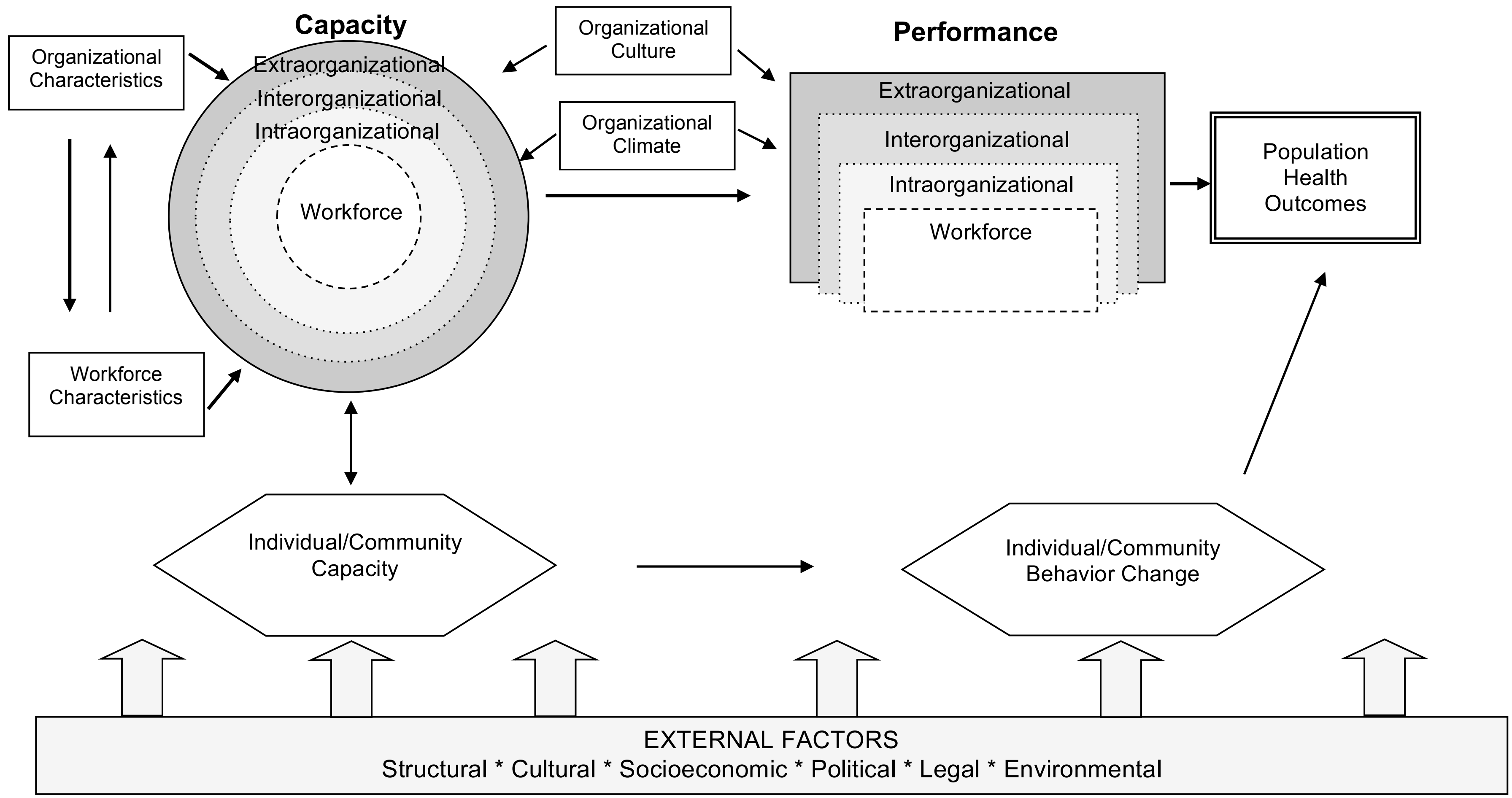
Future Research

The dissertation was valuable in identifying future research possibilities to improve public health workforce studies. The systematic review of public health workforce literature uncovered a limited set of research methods applied to workforce research, which could be expanded. To date, the research methods primarily used in PHSSR, including workforce research, have been cross-sectional and descriptive (Harris, Beatty, Barbero, Howard, Cheskin, Shapiro, & Mays, 2012). This dissertation features analytic studies, but also uses cross-sectional design, which is subject to many limitations in terms of causal relationships and generalizability of findings. Lack of availability of workforce data in public health makes longitudinal studies difficult to undertake. At present, the only known efforts to collect workforce characteristics at the individual level are being supported by national professional groups such as the Council of State and Territorial Epidemiologists, Association of Public Health Laboratories, and the Quad Council of Public Health Nursing Organizations, all in collaboration with the University of Michigan Center of Excellence in Public Health Workforce Studies. A collective effort to collect workforce data continuously on a national level is needed to ensure future studies can address the important questions identified by the PHSSR and workforce research agendas and move beyond descriptive analyses (Scutchfield, Howard & Mays, 2012).

Expanded Conceptual Model

The conceptual model used to guide this dissertation research was limited in scope and could be considered a subset of a larger theory-based conceptual model that could move toward linking workforce and organizational characteristics and capacity to performance and population health outcomes, which is the ultimate goal of this field of research. The expanded model draws on literature from organizational psychology, PHSSR, human resource management, and health care fields; the health care system capacity mapping work of Lafond et al. (2002) provides the basis for its structure (Figure 5.1). This model represents the relationships between variables that could be tested throughout a workforce research career, as it incorporates multiple levels and construct associations. The dissertation focused on the left side of the model, testing relationships between organizational and workforce characteristics, and organizational capacity.

Figure 5.1. Conceptual model for enhancing population health outcomes through public health workforce and organizational characteristics, capacity and performance



Theoretical Support.

Broadly, the expanded model depicts relationships between workforce characteristics and organizational characteristics; multilevel factors impacting capacity and performance of public health organizations and the workforce they employ; and the effect of performance on population health outcomes. Several theories support the structure of the model and its multilevel relationships, all of which can inform the design of future studies. As noted in Chapter I, human capital theory supports the concept that formal education, work experience, and on-the-job training are related to workforce capacity (Benson, 1978; Mincer, 1974; Schultz, 1971; Sweetland, 1996). Organizational Development theory plays a key role in understanding how organizations identify strategies and processes that enable them to be effective, with human resources among the most important components of an organization (Butterfoss, Kegler & Francisco, 2008). An expansion of the dissertation conceptual model, this theory supports the model pathways between organizational capacity, organizational climate and organizational culture (Steckler, Goodman & Kegler, 2002).

Relative to public health organizations, while little research provides an empirical basis for measuring organizational capacity, several studies have suggested variables within the construct of capacity that may impact capacity and lead to better performance. For example, Schwartz, et al. (1993) list personnel, program oversight, ability to plan and evaluate, ability to acquire resources for programs, expertise in community organization, needs assessment, data application, priority setting, and ability to link local and federal organizations as key elements of state health department capacity (Steckler et al., 2002).

Systems theory may also be relevant to multilevel structure of the expanded conceptual model. This theory was proposed in 1928, but was not applied to organizations until the last thirty years. The foundation of the theory suggests that all the components of an organization are interrelated; therefore, changing one variable may impact many others (Scott, 1981). The literature supporting this theory views organizational structure as the "established pattern of relationships among the parts of the organization" (French, Kast, & Rosenzweig, 1985, p. 348). Specific to this model, organizational and systems theories are useful in describing how public health organizations function and interact with the external environment and how they are influenced by external factors. The multilevel interactions of workforce, intraorganizational, interorganizational, and extraorganizational depicted in the model are supported by this idea of organizations as open systems, where one variable affects another.

Another theory that addresses multiple levels of the expanded conceptual model is empowerment theory. Empowerment has been defined as an enabling process through which individuals and communities take control over their lives and environment (Rappaport, 1984). Psychological, organizational and community empowerment all have relevance to the conceptual model, as they influence and are influenced by each other (Zimmerman, 1995). The workforce level is based primarily on psychological empowerment (PE) principles, particularly the concept that PE manifests itself in different perceptions, skills, and behaviors across the workforce; and that different beliefs, competencies, and actions may be required to master various settings (Zimmerman, 1995). Public health organizations should strive to create opportunities for the workforce to enhance skills and gain proficiency in achieving professional goals (Zimmerman, 1995). Examples could include the organization's provision of modifiable guidelines that assist employee decision making; facilitating a climate that encourages input of employees; establishing procedures that make information about the organization accessible to employees; and supporting workforce development opportunities to allow employees to gain and enhance skills. In addition, organizations should train and encourage employees to engage in empowering processes when working with communities or other organizations in health promotion activities.

The multiple organizational sublevels in the model are based on components of organizational empowerment (OE). The intraorganizational component includes variables and constructs that represent the internal structure and functioning of organizations that may be foundational for goal achievement, including supporting PE within its workforce (Peterson & Zimmerman, 2004). This sublevel also refers to the characteristics of each of these organizations that impact capacity and performance, such as leadership, financial resources, and organizational culture, all of which are important for development of collaborations between organizations. The collaborations, partnerships, and relations necessary for organizations to gain resources, share information, attain legitimacy, and accomplish goals represent the interorganizational sublevel of the model, which includes health departments, community-based organizations, academic institutions, nonprofit agencies, professional associations, and health plans, among others, as organization types.

Finally, the extraorganizational sublevel details efforts taken by organizations to shape or influence broader systems through public policy, practice, or deployment of resources, for example (Peterson & Zimmerman, 2004). The model shows that these three sublevels are interrelated with each other and the workforce level, consistent with the framework outlined by Peterson & Zimmerman (2004). Empowerment efforts across levels are required to enhance organizational capacity and performance to increase effectiveness.

Finally, a theory with potential relevance at the individual worker level is Self-Determination Theory (SDT), which tries to explain what factors compel human beings to be proactive, engaged, and motivated in to complete tasks and activities. In the context of this area of research, it may be helpful in determining why some workers are more motivated to perform satisfactorily than others, which could impact the capacity and performance of the organization as a whole. SDT posits that competence, relatedness, and autonomy are essential components for facilitating motivation (Ryan & Deci, 2000). SDT has been applied in many domains including education, organizations, physical activity, and health behaviors, among others. Future incorporation of SDT concepts in workforce research could elicit additional relationships between worker characteristics, competence, and organizational capacity.

Model constructs and pathways.

The pathways between organizational characteristics, workforce characteristics, and capacity were delineated in Chapter I. The conceptual work of Lafond et al. (2002) provides the basis for many of the remaining model pathways, with one being capacity's link to performance. In this model, capacity and performance are primarily considered at four levels: workforce, intraorganizational, interorganizational, and extraorganizational, with individual/community capacity also noted as an important construct. The link between individual/community capacity and workforce/organizational capacity is depicted as a reciprocal relationship because building capacity in one domain could increase capacity in the other. For example, an organization could use resources and personnel to enable a capacity building process within a community, which could result in implementation of health promotion programs at the individual or community level that lead to sustained behavior change (Hawe, Noort, King & Jordens, 1997; Goodman et al., 1998; LaFond, Brown & Macintyre, 2002). This method of capacity building seeks to transform individuals "from passive recipients of services to active participants in a process of community change" (Crisp et al., 2000). This, in turn, builds organizational capacity to engage in health promotion programming, for example, as the public health organization has assets within the community to assist with program implementation.

Despite an intuitive belief that capacity contributes to better performance, there is little understanding about the nature of the relationship. Capacity building is often identified as a need when performance is inadequate; however, the specific elements or combinations of elements of capacity are not heavily detailed in the literature (LaFond et al., 2002). In addition, while the literature may present examples of how to measure organizational capacity, the performance expectations as a result of increased capacity are not easily delineated. This is understandable given the multilevel nature of capacity and performance in organizations, but supports the need for additional empirical research in this area.

The model presents several key constructs at multiple levels, the most notable being capacity and performance. Additionally, organizational climate, organizational culture are key constructs that influence capacity and performance, and individual/community level behavior change impacts population health outcomes. Capacity at the workforce and intraorganizational organizational levels has been described in Chapter I. Interorganizational capacity variables relate to number and depth of community partnerships; resources, including financial and human (Minkler, Thompson, Bell, & Rose, 2001). Extraorganizational variables of capacity strengthen the organization's ability to meet goals of policy development and implementation, and resource distribution to communities (Minkler et al., 2001; Israel, Checkoway, Schulz, & Zimmerman, 1994). At the individual/community level, capacity encompasses several variables, which could include citizen participation in defining and resolving needs; leadership that provides direction for participant involvement; skills that include the ability to engage in group process, conflict resolution, and program planning; and access and sharing of community resources (Goodman et al., 1998). Additional organizational capacity variables are presented in the three organizational sublevels as follows.

The public health organization performance construct includes variables that affect the organization's success in achieving stated objectives. Performance is suggested to directly influence improvement of population health outcomes in the model. Performance and capacity are different but related concepts. At the workforce level, variables that impact performance include the level of workforce development programs (e.g. training, continuing education) completed by the worker; the support employees receive from co-workers and management to perform efficiently, such as provision of resources necessary to complete the job; the motivation of the employee to perform well; and the opportunity to contribute to the organizational mission (Novick, Morrow & Mays, 2008; Gebbie & Turnock, 2006; Baker et al., 2005). Variables that impact organizational performance at the intraorganizational sublevel are perceived to include number of public health programs developed and implemented; the evaluated effectiveness of the programs in meeting public health goals; and aspects of organizational empowerment that promote consensus building, and attribution of power across ranks of staff (Mays, Miller & Halverson, 2000; Gordon & DiTomaso, 2007; Handler, Issel, & Turnock, 2001). Interorganizational sublevel variables focus primarily on establishing effectiveness of partnerships, collaboration, and alliances to meet public health goals, and assessing whether the organization has successfully procured resources from other organizations (Crisp et al., 2000; Peterson & Zimmerman, 2004). Extraorganizational variables considered in the model relate to factors that impact the organization's effectiveness in promoting policy changes and distributing resources to the community. These variables include aspects of community engagement and empowerment; assessment of how well needed resources are distributed to community groups by the extraorganizational network; and whether health promotion policy implementation took place in the community around the health issue of concern (Minkler et al., 2001; Wandersman et al., 2004; Peterson & Zimmerman, 2004).

Organizational climate and culture are important constructs in this expanded model. Organizational climate is best described as the "mood or personality of an organization" (Steckler et al., 2002). Each organization has unique characteristics that distinguish it from other organizations, such as behavior and perceptions of leaders and employees; and organizational policies, environment, and social systems (Steckler et al., 2002). The climate of an organization influences whether new programs are successfully implemented (Steckler et al., 2002; Cullen, Baranowski, Baranowski, Hebert, deMoor, Hearn & Resnicow, 1999), thus supporting the path from organizational climate to performance. Several studies in various fields provide empirical findings of significant relationship between performance and organizational climate (Schneider & Snyder, 1975; Pritchard & Karasick, 1973; Hellriegel & Slocum, 1974). One such study in the early 1970s reported that organizational process variables were significantly related to the climate of the organization, and that perceived climate was significantly related to measures of organizational performance and job satisfaction (Lawler, Hall & Oldham, 1973).

Organizational culture is another concept of organizational development theory that is a critical component of the proposed model. While organizational culture and climate are closely related, they have distinct differences. Culture is conceptualized as "the deeper level of basic assumptions and beliefs that are shared by members of an organization, that operate unconsciously, and that define an organization's view of itself and its environment" (Schein, 1985, p. 6). Climate is sometimes referred to as the "psychology of an organization", while culture is its anthropology. Climate can be affected by a number of changing factors, sometimes immediately; in contrast, culture changes form slowly over time (Steckler et al., 2002).

Much like climate, business and organizational science literature support the relationship between organizational culture and performance (Gordon & DiTomaso, 2007; Marcoulides & Heck, 1993; Kotter & Heskett, 1992). Wilkens and Ouchi (1983) argue that different forms of culture affect performance differently. For example, some organizational culture may be irrelevant to performance, while some forms of culture will promote and some will inhibit efficient operation. Understanding culture within the organization is valuable for understanding why an organization underperforms or meets performance expectations.

The expanded model's external factors include structural, cultural, social, economic, political, legal, and environmental factors that may impact public health system capacity and performance. Structural, cultural, social, and economic implications are addressed in the following section. Examples of structural and cultural factors are further emphasized in the model through the addition of constructs of institutional racism and organizational culture. Political, legal and environmental factors are recognized as external policies, pressures, or procedures that have the ability to impact model constructs at multiple levels (LaFond et al., 2002). These factors are essential to consider for empowerment to be a distinct and meaningful concept in this model (Israel et al., 1994).

Summary

Overall, the findings of this dissertation are mixed in terms of providing evidence for the conceptual model (Figure 1.1). There does appear to be a reciprocal relationship between organizational and workforce characteristics (e.g. number of workers and competence of epidemiologists), although the specific characteristics may differ depending on the discipline. Workforce characteristics, such as education, type of degree, and years of experience, do exhibit significant positive associations with worker competence for epidemiologists. Similar models testing these associations with other groups of public health professionals would be helpful in validating these relationships. Organizational characteristics, particularly training opportunities and workforce composition, especially size of workforce, were significantly associated with organizational capacity in laboratories, although the path between minimum years of experience and capacity was not supported by the dissertation findings. Finally, the hypothesized reciprocal relationship between competence and capacity that is depicted in the model appears to be supported by the studies' findings, despite the Chapter III findings indicating an inverse relationship. Additional studies with refined capacity measures may inform further analyses of this important relationship.

The expanded conceptual model suggested to guide future research efforts emphasizes the use of theory to base study design and development of measures, which is currently a missing element in PHSSR. As noted in Chapter II, federal and foundation funding for PHSSR is starting to increase, drawing more attention to this important field and a prompting need to critically evaluate how research is being conducted. Building on the findings presented in this dissertation, employing new study methodologies, and using the research frameworks previously cited, public health workforce research efforts may be improved considerably and will likely be sustained for years to come.

Chapter V Literature Cited

Baker, E.L., Potter, M.A., Jones, D.L., Mercer, S.L., Cioffi, J.P., Green, L.W., … Fleming, D.W. (2005). Public health infrastructure and our nation's health. *Annual Review of Public Health, 26,* 303-318. doi: 0.1146/annurev.publhealth.26.021304.144647

Benson, C.S. (1978). *The economics of public education* (3rd ed.). Boston: Houghton Mifflin.

Boulton, M.L., Hadler, J., Beck, A.J., Ferland, L., & Lichtveld, M. (2011). Assessment of epidemiology capacity in state health departments, 2004-2009. *Public Health Reports, 126,* 84-93.

Boulton, M.L. (2009). Toward a more analytic framework for public health workforce research. *Journal of Public Health Management and Practice, Nov,* S62-S63.

Boulton, M.L., Lemmings, J., & Beck, A.J. (2009). Assessment of epidemiology capacity in state health departments, 2001-2006. *Journal of Public Health Management and Practice, 15,* 328-336.

Butterfoss, F.D., Kegler, M.C., & Francisco, V.T. (2008). Mobilizing organizations for health promotion: Theories of organizational change. In Glanz, K., Rimer, B.K., & Viswanath, K. (Eds.), *Health behavior and health education: Theory, research and practice, 4th Ed.* (pp. 341-345). San Francisco: Jossey-Bass.

Cioffi, J.P., Lichtveld, M.Y., & Tilson, H. (2004). A research agenda for public health workforce development. *Journal of Public Health Management and Practice, 10,* 186-192.

Consortium from Altarum Institute, the Centers for Disease Control and Prevention, the Robert Wood Johnson Foundation, and the National Coordinating Center for Public Health Services and Systems Research. (2012). A national research agenda for public health services and systems. *American Journal of Preventive Medicine, 42,* S72-S78.

Crawford, C.A.G., Summerfelt, W.T., Roy, K., Chen, Z., Meltzer, D.O., & Thacker, S.B. (2009). Perspectives on public health workforce research. *Journal of Public Health Management and Practice, 15,* S5-S15.

Crisp B.R., Swerissen H, & Suckett S.J. (2000). Four approaches to capacity building in health: Consequences for measurement and accountability. *Health Promotion International*, *15*, 99-107. doi: 10.1.1.120.8908

Cullen, K.W., Baranowski, T., Baranowski, J., Hebert, D., deMoor, C., Hearn, M.D., & Resnicow, K. (1999). Influence of school organizational characteristics on the outcomes of a school health promotion program. *Journal of School Health, 69,* 376-380. doi: 10.1111/j.1746-1561.1999.tb06433.x

Erwin, P.C., Greene, S.B., Mays, G.P., Ricketts, T.C., & Davis, M.V. (2011). The association of changes in local health department resources with changes in state-level health outcomes. *American Journal of Public Health, 101,* 609-615.

French, W.L., Kast, F.E., & Rosenzweig, J.E. (1985). *Understanding Human Behavior in Organizations*. New York: Harper & Row.

Goodman, R.M., Speers, M.A., McLeroy, K., Fawcett, S., Kegler, M., Parker, E., …Wallerstein, N. (1998). Identifying and defining the dimensions of community capacity to provide a basis for measurement. *Health Education & Behavior*, *25*, 258-278. doi: 10.1177/109019819802500303

Gordon, G.G., & DiTomaso, N. (2007). Predicting corporate performance from organizational culture. *Journal of Management Studies, 29,* 783-798. doi: 10.1111/j.1467-6486.1992.tb00689.x
Handler, A., Issel, M., & Turnock, B. (2001). A conceptual framework to measure performance of the public health system. *American Journal of Public Health*, *91,* 1235-1239.
Harris, J.K., Beatty, K.E., Barbero, C., Howard, A.F., Cheskin, R.A., Shapiro, R.M., Mays, G.P. (2012). Methods in public health services and systems research: a systematic review. *American Journal of Preventive Medicine, 42,* S42-S57.
Hawe, P., Noort, M., King, L., & Jordens, C. (1997). Multiplying health gains: The critical role of capacity building within health promotion programs. *Health Policy, 39,* 29-42.
Hellriegel, D., & Slocum, J.W. (1974). Organizational climate: Measures, research and contingencies. *The Academy of Management Journal, 17,* 255-280. Retrieved from: http://www.jstor.org/stable/254979.
Israel, B.A., Checkoway, B., Schulz, A., & Zimmerman, M. (1994). Health education and community empowerment: Conceptualizing and measuring perceptions of individual, organizational, and community control. *Health Education & Behavior, 21*, 149-170. doi: 10.1177/109019819402100203
Kotter, J.P., & Heskett, J.L. (1992). *Corporate culture and performance*. New York, NY: The Free Press.
LaFond, A.K., Brown, L., & Macintyre, K. (2002). Mapping capacity in the health sector: A conceptual framework. *International Journal of Health Planning and Management, 17,* 3-22. doi: 10.1002/hpm.649
Lawler, E.E., Hall, D.T., & Oldham, G.R. (1974). Organizational climate: Relationship to organizational structure, process and performance. *Organizational Behavior and Human Performance, 11,* 139-155. doi:10.1016/0030-5073(74)90010-5
Marcoulides, G.A., & Heck, R.H. (1993). Organizational culture and performance: Proposing and testing a model. *Organization Science, 4,* 209-225. Retrieved from: http://www.jstor.org/stable/2635200.
Mays, G.P., Miller, C.A., & Halverson, P.K. (2000). *Local public health practice: Trends & models*. Washington DC: American Public Health Association.
Mincer, J. (1974). *Schooling, experience, and earnings.* New York: Columbia University Press.
Minkler, M., Thompson, M., Bell, J., & Rose, K. (2001). Contributions of community involvement to organizational-level empowerment: The federal healthy start experience. *Health Education & Behavior, 28,* 783-807.
Novick, L.F., Morrow, C.B., & Mays, G.P. (Eds.) (2008). *Public health administration: Principles for population-based management* (2^{nd} ed.). Sudbury, MA: Jones and Bartlett.
Peterson, N.A., & Zimmerman, M.A. (2004). Beyond the individual: toward a nomological network of organizational empowerment. *American Journal of Community Psychology*, *34,* 129-145. doi: 10.1023/B:AJCP.0000040151.77047.58
Pritchard, R.D., & Karasick, B.W. (1973). The effects of organizational climate on managerial job performance and job satisfaction. *Organizational Behavior and Human Performance, 9,* 126-146. doi:10.1016/0030-5073(73)90042-1

Rappaport, J. (1984). Studies in empowerment: introduction to the issue. *Prevention in Human Services, 3,* 1-7.
Ryan, R.M., & Deci, E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55,* 68-78.
Schein, E.H. (1985). *Organizational culture and leadership*. San Francisco, CA: Jossey-Bass.
Schneider, B., & Snyder, R.A. (1975). Some relationships between job satisfaction and organization climate. *Journal of Applied Psychology, 60,* 318-328. doi:10.1037/h0076756
Schultz, T.W. (1971). *Investment in human capital: The role of education and research.* New York: The Free Press.
Schwartz, R., Smith, C., Speers, M.A., Dusenbury, L.J., Bright, F., Hedlund, S., …Schmid, T.L. (1993). Capacity building and resource needs of state health agencies to implement community-based cardiovascular disease programs. *Journal of Public Health Policy*, *14,* 480-493. Retrieved from: http://www.jstor.org/stable/3342879.
Scott, W.R. (1981). *Organizations: Rational, natural, and open Systems*. Englewood Cliffs, NJ: Prentice-Hall.
Scutchfield, F.D., Howard, A.F., & Mays, G.P. (2012). Public health services and systems research: An afterword. *American Journal of Preventive Medicine, 42,* S84-S86.
Steckler, A., Goodman, R.M., & Kegler, M.C. (2002). Mobilizing organizations for health enhancement: Theories of organizational change. In Glanz, K., Rimer, B.K., & Lewis, F.M. (Eds.), *Health behavior and health education: Theory, research and practice* (pp. 335-357). San Francisco: Jossey-Bass.
Sweetland, S.R. (1996). Human capital theory: Foundations of a field of inquiry. *Review of Educational Research, 66,* 341-359.
Wandersman, A., Snell-Johns, J., Lentz, B.E., Fetterman, D.M., Keener, D.C., Livet, M., Imm, P.S., & Flaspohler, D.M. (2004). The principles of empowerment evaluation. In Fetterman, D.M. & Wandersman, A. (Eds.), *Empowerment evaluation principles in practice* (pp. 27-41). New York: Thousand Oaks.
Wilkins, A.L., & Ouchi, W.G. (1983). Efficient cultures: Exploring the relationship between culture and organizational performance. *Administrative Science Quarterly, 28,* 468-481. Retrieved from: http://www.jstor.org/stable/2392253.
Zimmerman, M. (1995). Psychological empowerment: Issues and illustrations. *American Journal of Community Psychology, 23,* 581-599. doi: 10.1007/BF02506983