IDENTIFICATION, TOOL DEVELOPMENT AND VALIDATION, AND ASSESSMENT OF CORE COMPETENCIES OF PUBLIC HEALTH PROFESSIONALS IN UTTAR PRADESH, INDIA

by
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A dissertation submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy

Baltimore, Maryland
September 2020

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Abstract

Core competencies are the key knowledge, skills, abilities, and attitudes that the health workforce should possess to effectively deliver essential public health services like epidemiological surveillance and health promotion. Despite widespread recognition of the importance of core competencies, including by the World Health Organization, many low- and middle-income countries (LMICs) continue to face challenges in ensuring their public health workforce has the appropriate and adequate competencies. Contributing to this challenge are the absences of (i) agreed sets of core competencies, (ii) validated and reliable instruments to measure these competencies in these settings, and (iii) assessment of the individual-level factors associated with high competencies. This dissertation addressed these three research needs in Uttar Pradesh (UP), India's most populous state with almost 230 million people, and some of the nation's poorest health outcomes.

The dissertation has three distinct but interlinked papers. The aim of Paper 1 was to identify a recommended set of core competencies for public health professionals in supervisory and program management roles in UP. We used a multi-step, interactive Delphi technique to develop an agreed set of public health competencies. Paper 2 aimed to develop and validate a reliable set of items that form a self-assessment tool to evaluate core public health competencies. It used a cross-sectional survey—adapted from the consensus focused Delphi technique (Paper 1)—to collect data from mid-level and senior health professionals in the state. We used an Exploratory Factor Analysis (EFA) as the primary statistical technique that utilized the Principal Component Analysis (PCA) method for factor extraction. Paper 3 explored the association of individual-level variables, including self-assessed competencies and demographic

characteristics of health professionals, with performance on an objective core competency test. We relied on multiple linear regression to understand these associations.

Paper 1 produced a consensus set of 40 core competencies in public health across eight public health domains including public health sciences and leadership. Paper 2 generated a validated and reliable set of 37 items that form the core public health competency (COPHEC) tool. Paper 3 found the seniority of public health professionals to be significantly associated with objectively measured competencies. It also discovered generally low competency scores for all respondents, and it found that mid-level professionals had lower objective measurement scores compared to senior health professionals, but higher self-assessment scores, perhaps indicating a cognitive bias.

To our knowledge, this study presents a novel attempt to develop a framework and measurement tool for core competencies for practicing public health professionals in India. The framework and tool can be used to review current training practices, assess competencies of public health professionals, and inform workforce development efforts in UP or other resource-poor settings globally. The significant association of seniority (and not the other variables such as the duration on a job) with objectively measured competency indicates that responsibilities may matter more in ensuring higher competency than time on the seat. Low scores in the objective test indicate significant gaps in competencies to perform public health functions, and opportunities to deploy measures like competency-based training to address these gaps. Future research should test strategies to reduce cognitive bias by providing poor performers appropriate training, showing what good performance looks like, and providing meaningful feedback to strengthen competencies.

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Acknowledgments

This dissertation is an outcome of patient advice, invaluable input, and incessant support of multiple individuals. First, I want to acknowledge the intellectual contributions of numerous professors and researchers who advised me throughout the project. I am very grateful to my advisor, Dr. David Peters, who patiently guided me through the dissertation process, nurtured me to be an independent thinker and researcher, and trusted me to manage and carry out this research. I want to thank members of my Thesis Advisory Committee—Drs. Olakunle Alonge, Saifuddin Ahmed, Sara Bennett, and Qian-Li Xue, who provided the scholarly support to answer challenging theoretical and analytical questions. I also want to acknowledge Drs. Bhakti Hansoti, Joanne Katz, Elli Leonstini, Krishna Rao, Beth Resnick, Timothy Roberton, and Joshua Sharfstein who served either directly or as alternates during the departmental or university preliminary oral exams and provided input to advance my thinking on the topic. I want to thank other faculty including Drs. Cyrus Engineer, Courtland Robinson, and Brian Wahl for their mentorship and advice in the design and implementation of this study, as well as in my personal development as a researcher.

I am grateful for the generous financial support provided by Dr. David Peters, as well as by the Bill and Melinda Gates Foundation for the Uttar Pradesh Health Systems Strengthening Support (UPHSSS) project. I am humbled to receive other scholarships that financially supported me through my doctoral journey—Eckert-Fazen Endowment for Human Resources for Health in Low- and Middle-Income Countries, Health Systems Award, Richard Morrow Fund in Health Systems, and International Health Department Tuition Scholarship.

My journey was possible with the moral and emotional support of my family members, currently in the United States and Nepal. I am grateful to my friends and colleagues in the Health Systems program, the Department of International Health, and more broadly at the School of Public Health and the School of Medicine at Johns Hopkins.

I want to thank the JHU team in Lucknow for their encouragement and support that kept me going during my fieldwork in India. I would like to also acknowledge the Uttar Pradesh Technical Support Unit (UP-TSU) and faculty at the State Institute of Health and Family Welfare (SIHFW), for providing their valuable insights and local support. Last but not the least, I thank Rama ji, the cook in our apartment in Lucknow, and Rajnikanth, the fruit seller who showed up every day and continued to provide their services with love and dedication, rain or shine.

Dedication

I dedicate this dissertation to my beloved wife, Claire Margaret Petchler. You have done so much for me—from celebrating my first day of class, to being my unfailing confidant and editor-in-chief, to pausing your career to move across the world to India without hesitation. Your depth of sacrifice, love, and support is profound. I could not have done this without you!

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Abbreviations

AAID: Australian Agency for International Development
ACMO: Additional Chief Medical Officer
ADB: Asian Development Bank
CBTA: Competency-Based Training and Assessment
CMO: Chief Medical Officer
COVID: Corona Virus Disease
DALY: Disability Adjusted Life Years
DHS: Demographic Health Survey
DPM: District Program Manager
EFTE: Estimate-Feedback-Talk-Estimate
EPHFs: Essential Public Health Functions
GDP: Gross Domestic Product
GNI: Gross National Income
GO: Government Order
GOUP: Government of Uttar Pradesh
HIC: High Income Country
HWC: Health and Wellness Center
JHSPH: Johns Hopkins School of Public Health
KRAs: Key Result Areas
LMIC: Low- and Middle- Income Country
MO: Medical Officer
MOHFW: Ministry of Health and Family Welfare
MOIC: Medical Officer In-Charge
MPH: Master's in Public Health
NGO: Non-Governmental Organization
NHM: National Health Mission
PCA: Principal Component Analysis
PHC: Primary Health Care
SD: Standard Deviation
SES: Socio-Economic Status
UP: Uttar Pradesh
UPTSU: Uttar Pradesh Technical Support Unit
WB: World Bank
WHO: World Health Organization

1. Introduction

1.1. Study overview

1.1.1. Problem statement

The COVID-19 pandemic has highlighted the need for the public health systems and the human resources which staff such systems to possess competencies such as disease surveillance, risk communication, and leadership and management. While the pandemic has made the issue of public health competencies more pronounced, the global health community has long recognized the need to strengthen competencies of public health professionals to achieve Universal Health Coverage (UHC) (World Health Organization, 2006; Frenk et al., 2010a; World Health Organization, 2016c; Cometto et al., 2020).

The issue of improving competency is particularly relevant in low resource settings like Uttar Pradesh (UP). UP is the most populous state in India with over 230 million people and some of the worst health outcomes in the country (Ministry of Home Affairs, Government of India, 2011; NITI Aayog et al., 2019). The public health workforce that is in charge of addressing population health problems in the state is few in number—there are currently an estimated 9.1 health workers per 10,000 population compared to the WHO proposed Sustainable Development Goal index threshold of 44.5 health workers per 10,000 (World Health Organization, 2016c). Beyond the number deficit, the available health workers who have the responsibility to manage and lead public health programs are not trained in public health; most are clinicians. The Governments of Uttar Pradesh (GOUP) and India (GOI) have recognized this problem of skill deficit and underscored the need to improve appropriate training to these

health professionals (Government of India, 2017). Despite the recognition globally and in UP of the importance of competencies, there are significant theoretical and empirical gaps regarding what the necessary core competencies of public health professionals in low-income settings are; how we should measure these competencies; the breadth and depth of competency gaps among the public health professionals; and the factors that contribute to different competency levels among these professionals. This dissertation is an attempt to address these research gaps.

1.1.2. Research goal, questions, and objectives

The overarching goal of this study is to learn about public health competencies among the public sector health workforce in Uttar Pradesh (UP), India to guide future training and performance management in UP.

Within this overarching aim are three research questions this dissertation aims to answer:

1. What are the core competencies necessary for health professionals to provide essential public health services in UP?
2. What are the psychometric properties (validity and reliability) of the items in the instrument to measure core competencies?
3. What is the relationship between the self-reported core competency score and an objectively measured score of core competency test and what are the individual-level factors associated with the performance on the objective core competency test among public health professionals in Uttar Pradesh (UP), India?

These research questions inform the dissertation's three objectives, which are addressed in three papers that follow, and as outlined in Table 1.

Table 1. Research objectives by dissertation paper

Dissertation paper	**Research objectives**	**Innovation**
Paper 1	Objective 1: Develop a framework of core competencies for public health professionals in Uttar Pradesh.	This framework is novel in a low-resource setting like UP. Most other competency frameworks developed for practicing public health professionals are from high-income countries and regions.
Paper 2	Objective 2: Develop and validate items in a public health competency tool and assess their psychometric properties	While there are tools in the literature to measure competencies of the clinical workforce (physicians, nurses, and midwives), an instrument that measures core public health competencies, especially in a low-resource setting like UP, is unique.
Paper 3	Objective 3: Identify the individual-level factors associated with performance on an objective core competency test.	The study uniquely contributes to the theoretical and empiric understanding of the relationships between health workers' characteristics and their core competencies. While previous studies have explored these relationships in disciplines like clinical medicine, such exploration is rare in public health settings.

1.1.3. Organization of the dissertation

The dissertation attempts to achieve these research objectives in a series of five chapters.

The first chapter provides the study overview, introduces the relevant literature, and discusses the study context—the health system of UP; its demographic, epidemiological, and human resource for health profiles; and the Johns Hopkins project under which this dissertation was conducted.

The three distinct papers that make this research whole are presented in the subsequent chapters, and they are meant to "hang together" through a common thread of identification, tool development, and measurement of the core competencies of public health professionals in UP.

The second chapter (Paper 1) describes the process and results undertaken to identify the competencies and the domains that apply to public health professionals in supervisory or management roles in UP. We used a multi-step, interactive Delphi technique to develop an agreed set of public health competencies among Indian public health experts and government officials.

The third chapter (Paper 2) discusses the factor analytical framework—Exploratory Factor Analysis (EFA)—to explore the factor structure of core competencies. The use of EFA to statistically explore the latent measure of core competency in this setting is novel. This paper outlines steps undertaken to develop a valid and reliable set of items to form the Core Public Health Competency (COPHEC) index to assess the knowledge, skills, abilities, and attitudes of health professionals in supervisory and management positions in Uttar Pradesh (UP), India.

The fourth chapter (Paper 3) builds on the factor structure and factor scores from the second paper. Using multiple linear regression, it explores how individual-level factors like education level and seniority are associated with the objective measurement levels, which is measured through a set of test questions. We hypothesized that factors such as the duration on the job, education, and seniority would be positively correlated with the levels of objectively measured competencies. We also hypothesized that self-assessed competencies and objectively assessed competencies are positively associated—the higher the self-assessed

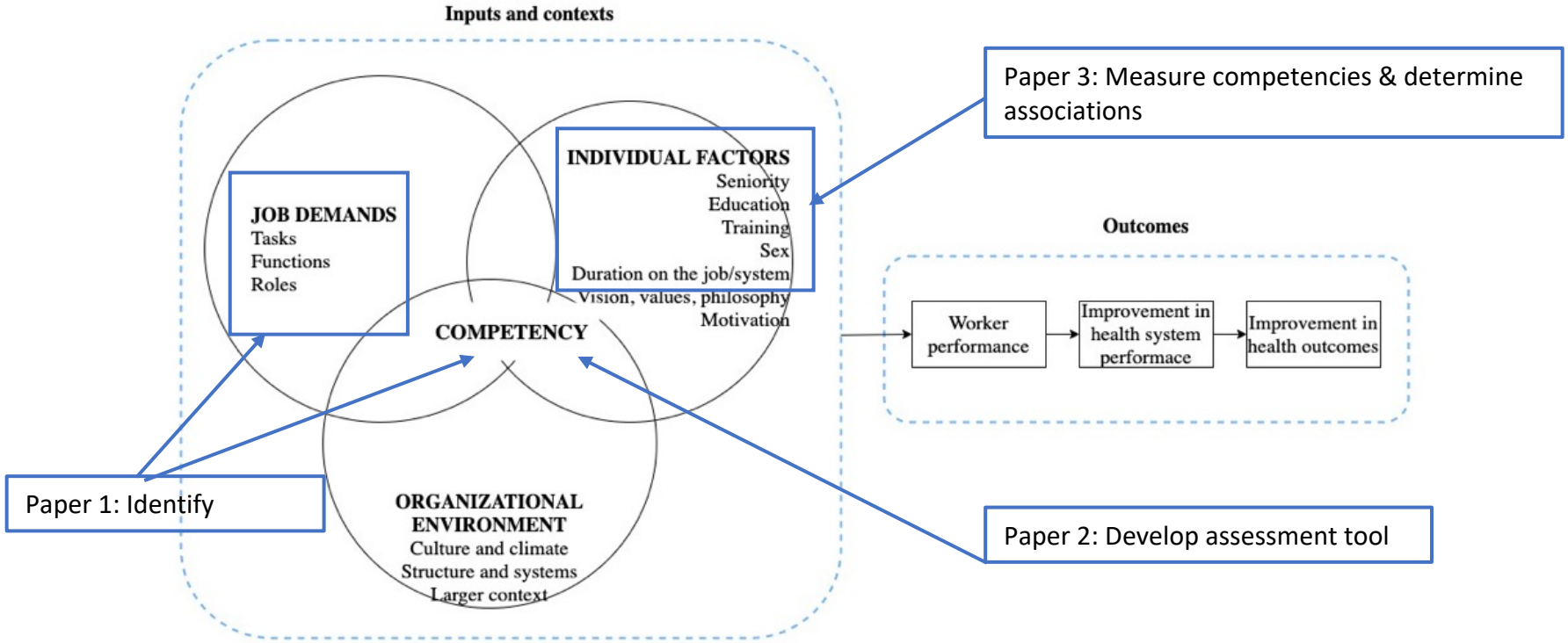
competencies, the higher the objectively assessed competencies. This paper fills important research gaps in public health competency measurement literature. Exploration of individual-level factors associated with public health competencies is rare, and almost all studies that measure the competency of health workers in low- and middle-income countries have focused on management competencies only.

The fifth chapter provides the conclusion to the dissertation. It summarizes the main findings across the three papers; discusses contributions of the overall work to the existing scientific literature, policy and program; and identifies future research direction.

1.1.4. Conceptual framework of the study

The conceptual framework for this dissertation is presented below. The framework is adapted from the theory of action and job performance (Boyatzis, 1982). As represented in Figure 1, the conceptual framework has two parts—(i) the inputs and contexts that shape competency, and (ii) the outcomes, which are based on the interplay of competency, inputs, and contexts.

Figure 1. The conceptual framework of the study



Adapted from: (Boyatzis, 2007)

Competency lies at the cross-section of individual factors, job demands, and organizational environment. Maximum competency can be expected from an employee when the individual characteristics of that employee align with the job demands and the nature of the organizational environment.

Individual attributes are described by employees' seniority—ranging anywhere from entry-level to senior management or executive-level positions; education—formal schooling; training—different types and levels of pre-service and in-service instruction; sex; time spent on the job or the system; individual vision, values, and philosophy; and motivation—the level of willingness to exert and maintain an effort towards organizational goals (Franco et al., 2002b). These health worker characteristics are important determinants of competency (Das & Hammer, 2005a; Franco et al., 2002a). For example, we can expect employees who are in senior positions in a public health system—described by seniority—may have a higher level of competencies because they have more experience doing their jobs than those who are in earlier stages of their careers. Similarly, we can expect employees who have prior training in public health to report a higher level of competence in this discipline.

The interconnection between motivation and competence is an important and extensively studied relationship, and it is worth elaborating here. This relationship is explained comprehensively by the competence motivation theory. The central thesis of this theory is that individuals are motivated to participate in activities in which they experience competence (Harter, 1978). Individuals are motivated to engage in mastery attempts for the purpose of developing and demonstrating competence in their selected fields. If their attempts to master a certain task or skill results in success, then they might experience perceptions of competence

along with perceptions of performance control—belief in their ability to control their performance. High perception of competence results in the feeling of pleasure that contributes to maintenance or an increase in motivation.

Job demands can be described by the tasks, functions, and roles, which need to be aligned with Essential Public Health Functions (EPHFs). EPHFs—used interchangeably with Essential Public Health Services (EPHSs) and Essential Public Health Operations (EPHOs)—describe the vital public health activities a health system should undertake (World Health Organization, 2018). These can include health surveillance, enforcement of public health regulation, research and innovation, and human resource development and training. While government health agencies tend to be the focal point to ensure these services, other actors such as civic groups, faith-based organizations, and even hospitals can contribute to their attainment. Numerous countries and regions—high income as well as low- and middle-income—have identified EPHFs specific to their settings. While there are variations across these frameworks, there are also similarities. Similarities pertain to functions like governance, finance, human resources, research, disease prevention, health protection, and preparedness for public health emergencies. (See Appendix 6. Essential Public Health Functions (EPHFs) from countries and regions globally).

EPHFs are particularly relevant for UP given the need for health systems strengthening in the state. EPHFs play an important role in the process. As Martin-Morno et. al (2016) describe in their paper, the idea that unites different functions in an EPHF framework is that each function is truly essential, and none should be understood or implemented in isolation from the other (Martin-Moreno et al., 2016). Such an idea aligns with the idea of health

systems strengthening which conceptualizes the health system to be complex, adaptive, and characterized by the interactions among various parts of the system, where no individual part should be understood in isolation from the other (Adam & de Savigny, 2012). EPHFs also help broaden the scope of public health actions beyond the health sector as some of these functions require multi-sectoral action to be realized. UP, rife with complex challenges in its health system, probably requires the collaboration of multiple actors well beyond the health sector to make meaningful reforms. EPHFs provide a framework to stimulate such collaboration.

Job demands should determine the types of competencies that are necessary to be effective in those jobs. Also, employees who hold those jobs should possess competencies that are necessary to successfully fulfill the jobs' demands. For example, a public health professional whose job demands them to diagnose health hazards in a community would ideally have competencies to determine quantitative and qualitative data and information (e.g., vital statistics) needed for assessing the health of that community.

Lastly, aspects of the organizational environment—culture and climate; structure and systems—have an important impact on the demonstration of competencies. Through the organization's efforts to improve worker capacity, provision of resources and processes to its employees, through feedback or consequences related to worker performance, and through more indirect aspects such as work culture, an organization can enable or prevent competency acquisition as well as demonstration (Franco et al., 2002b).

These organizational factors exist in larger political, economic, and social settings. For example, in UP, hierarchy plays a very strong role in society. Such hierarchy is evident also in the public health sector, which is rife with cumbersome centralized bureaucracies that

challenge the agency of individual health workers to make decisions. Work environments with hierarchical management structures and processes negatively impact health worker performance; these environments tend to be less conducive to task achievement as they allow less autonomy to individual actors (Franco et al., 2002a).

The interaction of competency, inputs, and contexts (organizational and broader contexts) shape health worker performance, which is one of the outcomes, as demonstrated in the figure above. Higher competencies of health workers can contribute to their high performance, however, that is not a guarantee. The relationship between competency and performance is mediated by factors such as supervision, feedback, and resource availability (Dieleman & Harnmeijer, 2006; Franco et al., 2002b). Other factors including worker characteristics (e.g., workers' attitudes, confidence, values, perceptions, and motivations), organizational factors (e.g., practices and attitudes of co-workers, the leadership of the director), and broader social factors (e.g., traditions and values of society, economic conditions of the health system, corruption) may also directly impact worker performance (Rowe et al., 2005). Worker performance impacts organizational as well as health systems performance, which influence the health outcomes of a population.

The above framework provides the theoretical backbone to support the three research papers of this dissertation, which focuses on the inputs and contexts part of the framework. The first research paper identifies health workers' core competencies, which is the central piece of the framework's first part—the inputs and the contexts. During the competency identification process in our research, job demands are taken into account so that the identified competencies are relevant for the work that employees do. Also, as described earlier, EPHFs

help in defining job demands. While UP has not created its unique EPHFs, there are certain services such as disease surveillance and health promotion that we can expect from the state. The core competencies identified in Paper 1 are influenced partly by these expected EPHFs. The second research paper develops a survey instrument for the measurement of competencies. The goal of the instrument is for it to be utilized in competency assessment, which helps in identifying areas where health workers need more public health training, an essential component of competency enhancement.

The third research paper measures the individual-level characteristics of the health workers to predict their competencies. The above framework informed the variables we measured for the third paper—sex, seniority, education, training, duration on the job, and duration in the health system. We were also guided by evidence from the literature during the variable selection process. Previous research shows that there are sex differences in self-perception of competency, with variance evident as early as in elementary school (Bouffard et al., 2003). Also, it is well documented that a person's perceptions of competence about another individual are influenced by that other individual's sex (Fiske et al., 2002). Similarly, previous research shows that more experience can contribute to higher levels of competency (Spencer & Spencer, 1993). Positive associations are also documented in the literature between competency and variables such as education level and prior training (Chang & Huang, 2005). These research findings are from disciplines other than public health. The influence of these demographic variables on competency is unexplored among public health professionals in low resource settings like UP, with objectively measured competencies as the outcome variable.

This dissertation measures competencies through self-assessment and objective test questions. While it quantifies variables such as worker characteristics, there are broader factors such as social, economic, and political, which form important parts of the conceptual framework but will not be measured. The entire sample is subject to the same set of broader factors, so there should be no variation in these factors that would help us to examine their impact on our outcome variable of interest—competency.

1.1.5. Significance of the study

There are five major contributions of this study to advance science, public health practice, and policy.

First, this study fills a gap in the scientific literature; this is the first-time public health competencies of health cadres that have public responsibilities will be assessed in the state of UP. Clinical competencies of some health workers have been explored in the past in India (Das & Hammer, 2005c), but systematic identification and evaluation of public health competencies of UP public health workers are novel. Research on competencies is particularly important because previous research shows that patients care a lot about the competence of their health care providers (K. D. Rao & Sheffel, 2018). Also, a few studies that do exist about the competencies of public health providers in low- and middle-income countries focus specifically on management skills, only an aspect of public health competency leaving out competencies such as analysis and assessment, partnership and collaboration, and communication (Fetene et al., 2019; Heerdegen et al., 2020; Munyewende et al., 2016). This provides a unique opportunity to explore the structure of public health competency in UP.

Second, this study has direct applications in terms of designing short-term training programs to improve public health competencies for health workers in the state, and more broadly in India. One of the practical reasons for pursuing competency as a research study was that during our formal and informal conversations with government and non-governmental partners of this study, there was a consistent emphasis on strengthening the competencies of public health workers through training. So, the results from the identification and assessment can give public health policymakers a common ground from which to work through the task of prioritizing training topics (Potter et al., 2000a). While some training courses cater to entry-level health cadres in UP, these courses were developed several years ago without a comprehensive competency assessment to inform the types of modules appropriate for the various cadres. There is also no formal obligatory pre-service training in areas of public health, leadership, or management, and common training is in clinical medicine. The mid-level health cadres continue to supervise and manage facilities that cater to large demography without specific training in public health. Previous assessments conducted in the state point that there remain significant gaps in management and leadership capacities—aspects of public health competencies—of these health professionals (McNatt et al., 2016).

Third, assessment of public health competencies is timely because the Indian national health policy 2017 has encouraged the states to create separate public health cadre (Ministry of Health and Family Welfare, 2017). The state of UP is considering developing a set of public health cadres. However, the process of releasing the policy, development of a new set of public health cadres, and their incorporation in the public health system are expected to take a few years. The competency identification, assessment, and subsequent training of current health

cadres can act as stopgap measures to address public health deficiencies until the proposed government public health cadres assume their positions. More importantly, such training can inform formal training that a public health cadre may need.

Fourth, findings could also inform a competency-based approach to human resource planning and management. This approach is helpful for planners and managers who have to make the optimal use of constrained human resources. It allows them to move beyond simply estimating numbers of certain professionals and plan instead based on a unique mix of competencies available from current health cadres (Tomblin Murphy et al., 2013). The findings can also be used to support workforce development by informing competency-based job descriptions for recruitment and performance management of human resources for health.

And lastly, the results of this study may serve as a guide for other researchers who would like to conduct identification and assessments of public health competencies in other states in India or other similar Low- and Middle-Income (LMIC) settings. This study can also be a starting point to explore how the competency of public health professionals relates to their performance and the performance of the health system at large.

1.2. Literature review

1.2.1. History and usage of competency

The concept of competency (or competence, used interchangeably) has been around for centuries, as early as the medieval guilds in which apprentices learned skills from a master and were rewarded with credentials once they met the standards of the trade (Horton, 2000; P. A.

Olson, 1983). However, the concept started taking hold in the academic literature only in 1959 when psychologist Robert W. White tied it closely with the concept of motivation (White, 1959). White claimed that competency arose from individuals' desire to affect their environment, and this drive was what guided them to be competent—to show they were qualified to perform a task. Over the decades, the concept of competency has taken different forms and meanings, usurping academic disciplines including higher education, industrial and organizational management, human resource development, clinical medicine, and even public health (Gruppen et al., 2012; Katz, 2015; Nodine, 2016). Competency-based training is the new norm in higher education. Its main feature is that it envisions the unit of progression for students from time spent in the classroom to mastery of specific knowledge and skills (Nodine, 2016).

Beyond academia, competency has received considerable focus in public policy around the world. An example of this is the New Public Management model in the 1980s that aimed to transform the public sector by making it more "business-like" (Ferlie et al., 1996). It envisioned public servants as public managers who needed to be equipped with competencies akin to those in the private sector (Horton, 2000). The goal was to improve the efficiency and performance of the public sector. High-income countries (HICs) like Belgium, Netherlands, and the US have utilized the concept of competency to push for public sector human resources reform. The concept is not limited to reform in HICs alone. Tanzania, a low-income country, used competency as a basis for driving public service delivery reform, while similar opportunities to drive civil service reforms have been identified in countries like Mozambique, Nepal, and Sri-Lanka (Marijani, 2017). International agencies like the Asian Development Bank

(ADB) and Australian Agency for International Development (AAID) have long encouraged an improvement in competency-based training and education in countries like Bangladesh, Bhutan, and the Maldives (Asian Development Bank & Australian Agency for International Development, 2014).

In India, the central government's Department of Personnel, in collaboration with the United Nations Development Program (UNDP), initiated the project to start a competency-based system of strategic human resource management for the Indian Civil Service in 2011 (V. Gupta et al., 2018). The outcome of this effort was a "Competency Dictionary" that identified 25 core competencies across various roles and positions of the civil service employees (Government of India & UNDP, 2014). Associated with this effort is the National Training Policy of 2012, which asserted that career progression and recruitment in public health jobs should be based on an individual's competencies required for that post (Government of India, 2012b). Similarly, the national health policy of 2017 discusses the role of competency-based courses as a way to develop the cadre of mid-level primary care providers (Ministry of Health and Family Welfare, 2017).

In 2004, India's Ministry of Health and Social partnered with the World Bank to assess the state of Essential Public Health Functions (EPHFs) in the country (M. D. Gupta & Rani, 2004). The tool used for the assessment was adapted from the Centers for Disease Control and Prevention's (CDC) National Public Health Performance Standard Program and the Pan American Health Organization. It was modified for use in India based on feedback from experts and World Bank counterparts in India. Questionnaires were self-administered among 119 senior public health officials at the national, state, and district levels, and the questions were

meant to elicit a self-evaluation of the public health system. While there was no external evaluation conducted to objectively assess India's EPHF standards, the study found that there was the perception of weakness of MoHFW's leadership competencies—specifically around conflict management, leadership development, and development of teamwork. The overall initiative led to other encouraging projects. For example, building on this EPHF evaluation initiative, the district government in Karnataka partnered with the World Bank from 2006 to 2017 to strengthen existing health services innovate in service delivery and health financing (The World Bank, 2018; World Health Organization, 2018). While these initiatives focused on EPHFs, they are important precursors to competencies. EPHFs can provide valuable direction for policymakers and managers to identify competencies that need to be further strengthened to achieve those EPHFs and improve health system outcomes.

1.2.2. Frameworks of core competencies for public health professionals

Around the world, efforts to develop core competencies for public health professionals have largely been made in High-Income Countries (HICs) and regions (Foldspang et al., 2018; Public Health Agency of Canada, 2008; The Council on Linkages, 2014), for the clinical health workforce (Berendes et al., 2011; Das & Hammer, 2005d; World Health Organization, 2016d), researchers working in low-resource settings (Alonge et al., 2019), and public health academic programs (Calhoun et al., 2002, 2008, 2012). In India, the Public Health Foundation of India (PHFI), the Union Ministry of Health and Family Welfare (MOHFW), and others have developed core competencies frameworks for Master's in Public Health (MPH) programs and community medicine fellowships (Ministry of Health and Family Welfare, Government of India, 2018; Raghav et al., 2016; Sharma et al., 2013).

Here are some of the country-led efforts to codify core competencies for public health professionals:

Canada

The Core Competencies for Public Health in Canada Release 1.0 was developed in 2007 by the Public Health Agency of Canada (Public Health Agency of Canada, 2008). This framework categorizes 36 competencies in 7 domains: public health sciences; assessment and analysis; policy and program planning, implementation and evaluation; partnerships, collaboration and advocacy; diversity and inclusiveness; communication; and leadership. This model does not provide different sets of competencies for different levels of public health practice; however, it does illustrate each statement with one or two examples for a frontline provider, a consultant/specialist, or a manager.

Europe

The European list for the Public Health Professional was developed in 2018 by an independent organization, The Association of Schools of Public Health in the European Region (ASPHER). The competencies are categorized into six groups: methods in public health; population health and its social and economic determinants; population health and its material-physical, radiological, chemical and biological-environmental determinants; health policy, economics, organizational theory, leadership and management; health promotion, health protection and disease prevention; and ethics. These public health core competencies are geared towards fulfilling WHO's Essential Public Health Operations (EPHOs) (WHO Regional Office for Europe, 2012).

New Zealand

The Public Health Association of New Zealand developed the Generic Competencies for Public Health in Aotearoa-New Zealand to provide a baseline for competencies that are common to all public health roles across all public health sectors and disciplines (Public Health Association of New Zealand, 2007). The framework lists 34 competency statements across 12 domains of public health practice—health systems; public health science; policy, legislation, and regulation; research and evaluation; community health development; Te Tiriti o Waitangi[a]; working across and understanding cultures; communication; leadership, teamwork, and professional liaison; advocacy; professional development and self-management; and planning and administration. Uniquely, this framework lists performance requirements for each competency statement as specific behaviors that a public health worker needs to demonstrate to be deemed competent in that particular competency.

Pan American Health Organization (PAHO)

In 2013, PAHO developed the Regional Core Competency Framework for Public Health (RCCFPH) taking into account the vast diversity of the public health workforce, infrastructures, and systems in the Americas region (Pan American Health Organization, 2013). The Essential Public Health Functions (EPHFs) were used as the starting point for the preparation of this framework (Pan American Health Organization, 2008). The 65 competencies in this framework

[a] Te Tiriti o Waitangi is a treaty signed in 1840 by the British Crown and chiefs of the indigenous Polynesian people (called Maori) from the North Island of New Zealand. The document is central to the identity, history, and constitution of the country as it defines the political relationship between New Zealand's government and the Maori population. This public health domain catalogs competencies as it relates to the knowledge of this treaty, participation with the Maori to improve their health, understanding Maori's concepts of health and wellbeing, and using culturally appropriate values while working with this indigenous population.

are categorized into six substantive domains—health situation analysis; surveillance and control of risks and threats; health promotion and social participation; policy, planning, regulation and control; equitable access and quality of individual and public health services; and international/global health. Also included in the framework is a cross-cutting set of dimensions or attributes that should be considered in every domain: planning, management, evaluation, communication, leadership, research, and information and communication technologies (ICT).

Spain

The Spanish Public Health and Health Administration Society (SESPAS) and the Spanish Society of Epidemiology (SSE) developed a framework called Professional Competencies in Public Health in 2006 (Benavides et al., 2006). The framework outlines 76 unique competencies across 11 public health activities, which are then categorized into three overarching functions of the public health system: assess the health needs of the population; develop health policies; and guarantee the provision of health services. The authors of the framework call for a periodic review of the competencies and expansion of its use across public health professional societies.

United Kingdom

The UK's Public Health Skills and Knowledge Framework (PHSKF) was produced through the collaborative efforts of lead public health agencies across the UK including Public Health England, Public Health Wales, NHS Scotland, and the Public Health Agency of Northern Ireland (Public Health England et al., 2019). Published in 2016, the framework lists 13 domains (called functions) across three main areas–Technical, Context, and Delivery. These functions are further divided into subfunctions, which define the skills and knowledge (competencies) expected of the public health workforce expected to deliver on public health outcomes.

United States

In 2014, the Council of Linkages Between Academia and Public Health Practice—a collaborative of 23 national organizations in the US—developed the core competencies for public health professionals by identifying between 7 to 16 competencies for each of 8 domains that cut across public health discipline (The Council on Linkages, 2014). These eight domains are analytical/assessment skills; policy development/program planning skills; communication skills; cultural competency skills; community dimension of practice skills; public health sciences skills; financial planning and management skills; leadership and systems thinking skills. The framework is designed to align with Essential Public Health Services (EPHS) defined by the Centers for Disease Control and Prevention (Centers for Disease Control and Prevention, 2014) (See Appendix 6 for these 10 essential services). The framework envisions the practice of public health in three Tiers—Tier 1 includes frontline or entry-level staff who carry out the day-to-day tasks of public health organizations and are not in management positions. Tier 2 includes program management or supervisory level staff whose responsibility may include implementing and evaluating programs; or managing timelines, community partnerships, and work plans. Tier 3 level individuals include senior management/executive level staff who are the leaders of public health organizations who typically have the responsibility of overseeing major programs and setting the vision for the organization.

These public health competencies are used in assessing workforce knowledge and skills, identifying training needs, generating workforce development and training plans, crafting job descriptions, and conducting performance evaluations. While there are other frameworks of competencies, most of them are either too generic or they focus on competencies measured

through educational programs rather than workers in the field. For example, the widely used universal competency framework includes a generic set of competencies like leading and deciding, interacting and presenting, which could be applied to public health settings. Potter and colleagues assessed the use of this framework to establish a model training agenda for the public health workforce. They found that while the universal competencies framework provides a useful starting point, it is not sufficient for assessing and meeting the specific training needs of health providers (Potter et al., 2000b).

This dissertation builds on these previous efforts and aims to identify the core competencies for public health professionals in supervisory or program management roles in UP.

1.2.3. Definitional, conceptual, and theoretical challenges to competency

Despite the usage of competency in higher education, personnel development, policy reform, and public health practice, there are persistent issues relevant to competency. The first issue is definitional. There seems to be no consensus on the definition of competency (Flinkman et al., 2017). Some scholars have defined it as a person's underlying attributes like skills, knowledge, abilities, and attitudes (Boyatzis, 1982; Le Deist & Winterton, 2005; Sternberg & Kolligian Jr., 1990). These scholars have defined it as the quality possessed by an individual, regardless of how it manifests in the workplace. Other scholars have understood competence by linking it strictly with observable performance (Boam & Sparrow, 1992; Bowden & Masters, 1993; Short, 1984). See Appendix 1 for selected competency definitions and their sources.

Mills et al. (2020) argue that the source of confusion in competency definitions is the conceptual differences in the two different ways the competency concept has emerged. The

first emergence happened in the United States in the 1970s with behavioral competencies being prominent in the education sector. This approach described competencies as attributes of a person, namely, the knowledge, skills, attitude, and behaviors. While it aimed to support workers' attainment of the highest level of proficiency, it argued that the development of competencies as a continuous process. The second emergence happened in the 1980s in the United Kingdom around functional approaches to competencies with employment as the focus. The functional approach is related to the roles, activities, or tasks that an individual worker could perform. The approach envisioned competencies as discrete—a worker was either competent in a task or not. The goal was to achieve the highest production at the lowest costs. Mills et al. argue that the inability to clearly understand the underlying conceptualizations has led to inconsistent usage of the term. So, they suggest a reconceptualization of the competency framework by combining these two distinct frameworks and redefining the terms associated with these frameworks. The new concept has four features: it differentiates between competency and activity, it distinguishes attributes from competencies and activities, recognizes competency as evolving through increasing levels of proficiency, and conduciveness to translation in other sectors as well.

The most comprehensive definitions of competency include the knowledge, skills, abilities, and attitudes that the health workforce should possess to effectively deliver essential public health services. Knowledge relates to understanding facts, procedures, concepts, theories. Skill is the capability (learned) that one brings to a task and is about the application of knowledge. Ability is being able to accomplish something; it represents traits (innate) that

enable one to perform. Attitude includes the emotions, beliefs, and values that motivate behavior.

Apart from the issues of the definition, there seems to be a confusion about the differences of competency with concepts like capability, with some organizations developing a capability model as a step ahead than the competency model (Deloitte, 2018). Authors who purport the capability model claim that competency paradigms are old, and there should be new ways of developing and managing individuals and organizations (Fraser & Greenhalgh, 2001; Hase & Davis, 1999; Tamkin, 2015). They describe capability as not just the possession of knowledge, skills, abilities, and attitudes, but also the ability to learn new things and be flexible in distinct circumstances. Despite the new spin in the terminology, the challenge of definitions still persists in the capability concept with definitional convergence in the literature. Other researchers have interchangeably used competency with performance, which relates to worker's actions (Eraut, 1998). However, there is debate on the extent that performance can be predicted by competencies, given that there may be individual-level factors like past experiences, types of training, and motivation as well as systems related factors like workplace barriers that also impact performance (Kak et al., 2001).

There are different versions of competency as there are definitions. For example, the concept of core competencies came to prominence after the publication of a seminal article by Prahalad and Hamel to describe the essential resources or capabilities that provide an organization a competitive edge in business (Prahalad & Hamel, 1990). The authors linked core competencies to a firm's core products, which are the physical embodiments of these competencies. Core competencies are different from functional competencies, which describe

the job-specific competencies that are technical or operational in nature (Cheetham & Chivers, 1996). These are different from organizational competencies, which entail the collection of competencies that make up the behavioral roadmap that is directly related to the performance of organizations (Dosi & Teece, 1998). In other words, these competencies make the organization whole, providing it the essential ingredient to succeed in the competitive market. There are also other types of competencies that are commonly used in the human resource management literature—technical competency, behavioral competency, management competency, leadership competency—all of which have varying definitions and usages. See Appendix 3 for these definitions.

The concept also has faced other more theoretical criticisms. Researchers have criticized the concept and the associated terminologies as "fuzzy" or "shifting sand" (Chen & Chang, 2010; Markus et al., 2005). Some have argued that the concept of competence should be contextual, and currently it separates the learner from the political, social, and economic environment that vary in terms of contexts (Brightwell & Grant, 2013). The highly rigid credentialing system, atomistic understanding of knowledge, and commodification of certifications, all of which are derived from the concept of competencies, perpetuates inequality in access to education (Bernstein, 2000). The argument is that the vocational training and education, which form the foundation of competency-based training, locks marginalized groups out of the reach of the powerful knowledge generation process represented by traditional academic disciplines. Bernstein argues that competency-based education that promotes vocationalism and training denies the working class and other disadvantaged groups

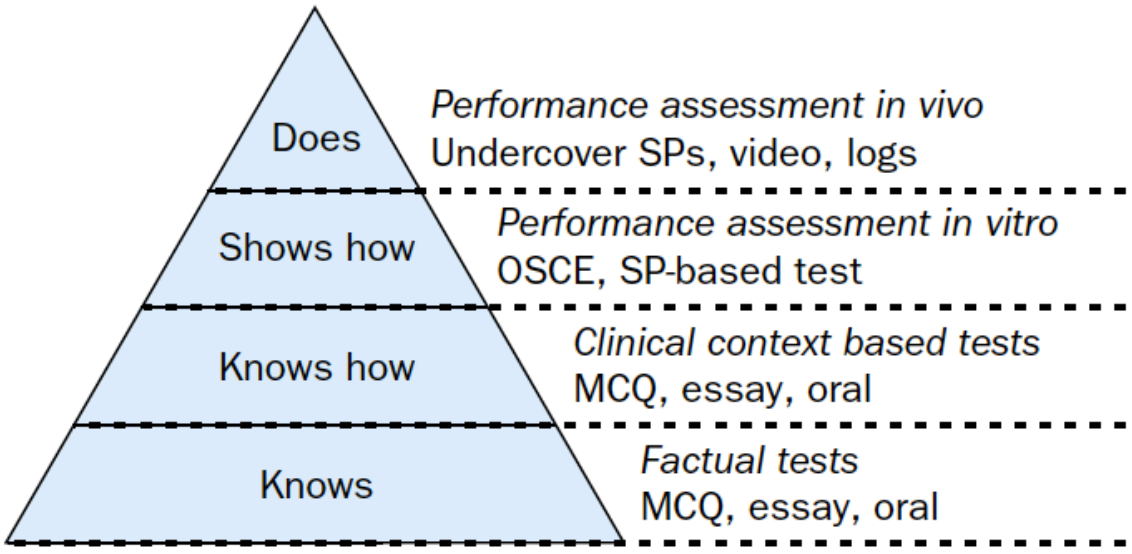
from access to often powerful, abstract, conceptual knowledge as these students often have little access to structuring principles of disciplinary knowledge (Wheelahan, 2007).

1.2.4. Methods for competency assessment

Despite these criticisms, competencies continue to be the basis for accreditation, credentialing, regulation, and training in public health. Ministries of health and professional organizations must ensure that competency expectations are met to achieve performance and quality standards. Competency assessment becomes an essential element of this process.

Assessment of competencies is not novel. There have been numerous previous efforts in other fields like clinical medicine, aviation, and engineering to measure competencies of individuals and organizations (Kiran et al., 2011; Leigh et al., 2007; Wass, Vleuten, et al., 2001). Competency assessments in these fields have tended to include discrete physical maneuvers allowing examiners to observe participants' responses. In clinical medicine, specifically, there are have been multiple ways to conduct competency assessment (Kak et al., 2001). These measurement techniques can be categorized based on Miller's framework for clinical competence assessment shown in Figure 2 (Miller, 1990). The pyramid describes four hierarchies of assessment.

Figure 2: Miller's triangle of competency assessment



Adapted from (Miller, 1990; Wass, Vleuten, et al., 2001).
SP=simulated patients; OSCE=objective structured clinical examination; MCQ=multiple-choice questions

The first/bottom level (knows) relates to the knowledge of the health worker, which deals with the facts and information that the health worker possesses. Such knowledge can be tested using factual tests like multiple choice questions, oral exams, and essays. Traditional examinations in higher institutional tend to focus on this level of assessment (Boud & Falchikov, 2007).

The second level (knows how) relates to assessing the skill with which the knowledge can be applied. Competencies in this level can be tested through context-based exams. Apart from essays and oral exams, these can include the use of patient cases in which the respondent is expected to answer to a certain hypothetical scenario, and they are scored on a pre-determined scale. The patient vignette is a type of written competency test in which short case histories are presented, and test-takers are asked pertinent questions about what actions should be taken if the portrayal were real (Peabody et al., 2000). Computerized tests can also

be categorized in this level. There are variations of these tests, but usually, examinees are not necessarily cued to patient problems or possible courses of action by the presentation of questions with decision options. Instead, a brief introduction may be presented, and the desired actions are then specified by the examinee through 'free text' entry using the computer keyboard (Jurecka, 2008). These responses are then evaluated by an examiner.

The third level (shows how) relates to health workers demonstrating if they can perform in a structured in-vitro environment. In other words, operationalizing a competency into action but in a pre-arranged context. Objective structured clinical examination (OSCE) can be categorized in this level. In OSCE, clinical skills are measured using a consistent, structured format of rotating stations. These stations include a wide range of cases and structured assessments, in which candidates have to use their competencies to address the problem at hand. A less popular technique to measure competency within this level are through the use of unstandardized real patients. Respondents are then judged on their clinical skills, usually by their supervisors. These tests are increasingly being challenged on the grounds of unreliability.

Lastly, the fourth level (does) facet of the competence assessment relates to the assessment of competencies the health worker is actually able to perform at work. This can be assessed using undercover standard patients, videos, medical records and logs, and patients' assessments of the health workers. The review of medical records is a low-cost technique, in which the clinical features such as the family history, symptoms, and other clinical features are extracted to analyze whether the diagnoses and treatments were according to the standards (Payne, 1979). However, competency cannot be reliably inferred from performance, as there

are many other pathways to performance including workplace culture, motivation, access to resources, patient mix, etc. Further, medical records tend to be incomplete (Payne, 1979).

Apart from these, there are other forms of assessments including the multi-method assessment that combines multiple assessment techniques discussed above. This includes a 360-degree assessment, which involves getting self-assessment as well as assessment from the supervisor and subordinates. Appendix 2 shows these and other competency assessment methods, their descriptions, and levels of competency assessment by Miller's framework.

1.2.5. Challenges to public health competency assessment

This section discusses the conceptual and methodological challenges to competency measurement in public health, especially in low- and middle-income countries. Some of these challenges are not unique to public health. For example, the field of professional psychology has gone through these reflections in the past (Lichtenberg et al., 2007a). Although, some are public health-specific.

Conceptual challenges

The first challenge is the lack of agreement in the public health profession about the key competency domains. The debate on definition and versions of competency is partly alleviated by public health organizations like the Council on Education for Public Health (CEPH) in the United States that define and then require public health universities and colleges to offer a minimum level of a set of public health competencies to their students (CEPH, 2020). Also, the Council on Linkages between Academia and Public Health, a consortium of public health organizations in the United States has defined core competencies as the consensus set of foundational skills desirable for professionals who engage in the practice, education, and

research in public health (The Council of Linkages Between Academia and Public Health Practice, 2017). Similar agencies exist elsewhere as well—Association of Schools of Public Health in the European Region (ASPHER) in Europe, and Council of Academic Public Health Institutions Australia (CAPHIA) in Australia (Council of Academic Public Health Institutions Australia, 2016; Council on Education for Public Health, 2016; Foldspang et al., 2018). The concept of Entrustable Professional Activities (EPA), which is a set of professional activities or units that a trainee is expected to fulfill once they have attained specific competencies, is also helping with the standardization of the competencies (Cate, 2005).

However, these accreditation bodies and EPA do not exist in many low- and middle-income countries. In fact, the concept of public health professionals or the education they should receive is largely limited to medical schools and clinicians with a focus on community medicine (Sharma & Zodpey, 2011). This may explain why there are wide variations in how public health education is imparted and competencies that public health professionals are expected to exhibit. Only recently, the Indian government came up with a list of competencies that all public health programs need to include in their MPH curriculum (Ministry of Health and Family Welfare, Government of India, 2018). While the document provides a broad outline for public health programs to adhere to, there is no evidence to support that public health programs in India have actually integrated them into their curriculum. This lack of informed and clear measurable learning objectives also impacts the measurement process.

The second theoretical challenge relates to the concept of public health itself. Boundaries of public health are varied around the world, and there is a lack of agreement about what public health actually is. In many settings, public health is perceived to be services that are

provided by the government to the public. In other settings, public health is usually lumped into the department of clinical medicine, making it challenging for many to know the differences between the two. The confusion about the boundaries of public health impacts the expectations of the core functions that public health professionals are supposed to fulfill (Gebbie et al., 2002). Traditionally, clinicians and nurses have assumed the roles of public health professionals (Goldsteen et al., 2014). So, the concept of having individuals trained specifically for public health is relatively new in many low- and middle-income settings.

These challenges directly impact the accreditation process, standardization, and measurement of public health competencies. Regardless, some of these challenges are gradually being addressed by standardizing public work professional training globally (Tulchinsky & McKee, 2011).

Measurement challenges

Apart from the theoretical challenges, there are operational challenges to competency measurement.

The first challenge relates to the question of whether an instrument is measuring competencies or just knowledge. As discussed earlier, competencies are a combination of knowledge, skills, abilities, and attitudes. However, most tools, especially within professional public health education, seem more effective in assessing knowledge than skills, abilities, or attitudes; skills better than abilities or attitudes; and abilities better than attitudes (Lichtenberg et al., 2007b). Attitudes are challenging to measure in public health, or any other discipline, and usually, behavioral measurements are used as proxies to quantify attitudes. For knowledge assessment, various methods such as examinations, the passage of skills course, supervisor's

reports have been utilized in the past. However, these methods often lack reliability, validity, and fidelity to practice. The issue of fidelity, which is the extent to which a measurement technique can duplicate or capture the real task, is particularly important. Established approaches to measuring public health competencies—which may be measuring only knowledge—are administered in isolation (in classrooms, for example) with little regard to how a student or professional would apply that competency in a wide range of professional situations. Assessments in public health usually do not involve observations of the person being evaluated in a simulated or actual situation and are usually devoid of the feedback from the end-users—patients, community members, and the population at large. High fidelity methods, which closely resemble the demands of the job, include techniques such as case studies, vignettes, and simulations. These methods could strengthen competency assessment, but they are also resource-intensive—labor, cost, and time-wise. The other concern relates to the generalizability of the assessment—the higher the fidelity of an assessment procedure, the lower the generalizability from one setting to another (Lichtenberg et al., 2007a).

While some of these issues are relevant to the measurement of competencies generally, some are particularly pertinent to public health. Almost all of the efforts in competency assessment in the field have focused on self-assessments. For example, Issel et al. conducted a self-assessment of public health competencies in the US among public health nurses (Issel et al., 2006b). The study evaluated the public health competency of practicing public health nurses from 50 local health agencies and public health nursing faculty from 31 nursing programs in Illinois. The respondents self-rated themselves on each competency statement based on a 5-point Likert scale ranging from 1=need to be taught this, to 5= able to do and teach this to

others. Another study assessed competency among Primary Health Care clinical nurse managers in two provinces of South Africa (Munyewende et al., 2016). They developed their own tool that measured competencies in domains like monitoring community health status; mobilizing community partnerships; enforcement of laws, communication, leadership and management; and staff management. In their approach, the nurses, their supervisors, and subordinate nurses completed a questionnaire that rated the nurses against these domains, a 360-degree assessment. While 360-degree assessments may be more reliable than self-assessments alone, they are still based on perceptions, with no objectively verifiable ways to measure response bias.

Observational approaches to competency assessment, through the use of anatomical models or full-scale simulators like manikins that are common practice in clinical medicine, may be inappropriate or impractical in public health. Even in fields that allow such distinct physical maneuvers, researchers have recognized that measurement method other than self-reports to be highly resource-intensive, requiring meticulous observations and application of skills test (Epstein & Hundert, 2002).

There are other approaches to competency assessment in public health, including vignettes. Vignettes are short hypothetical stories with specific circumstances that allow participants to respond. These responses—which are a reflection of respondents' competency—are then judged, based on a pre-specified evaluation scorecard (Finch, 1987). Despite its usefulness, the vignette technique is quite expensive and tends to demand a lot of time from the respondents. There are newer approaches to cognitive testing such as the use of features like video games (Greiff et al., 2014; Shute et al., 2015), however, the feasibility and acceptability of these

approaches in LMICs are unknown. Despite these challenges with measurement, there is considerable recognition among the professional public health community that the assessment of competencies is important.

The literature described above informed our research approach and methods. We recognized the need to develop a core competency framework that was applicable to public health professionals in the state of UP. This step would be fundamental in informing the design of a competency assessment tool applicable in this setting and any further work to define functional or technical competencies in the state. Based on the literature, we also realized that there are various methods to measure competencies, with each method having its advantages and disadvantages. The survey methodology was deemed appropriate for a few reasons. First, it is the method of choice for public health competency assessment, as some of the other methods like role plays are unfeasible for reasons described above. The survey method is also relatively inexpensive, and it is not as time-consuming for the respondents. Time was an important consideration as the health professionals we approached for this study—both mid-level and senior—tend to report being very busy with multiple professional demands. Also, the survey technique was relatively easy to administer (compared to say, vignettes), and it allowed us to collect data from a large number of respondents in a rather short amount of time. These considerations coupled with the practicalities of the parent project in which this research was conducted (e.g., a fixed timeline of the grant) informed our research approach and methods.

1.3. Study context

1.3.1. Health system in India and UP

There is a long history of traditional medicine in India, dating back centuries (World Health Organization, 2001). While some of these traditional practices continue to exist today, the current public health structure rests mostly on the vision conceptualized by the Bhore Committee in 1946 (Government of India, 1946). The Bhore committee recommended a three-tiered integrated preventive and curative care system, which includes primary, secondary, and tertiary levels. This system is prevalent today. Primary health care is delivered through two types of health care institutions–Sub-Center (SC) and Primary Health Center (PHC). An SC is the most peripheral health institution and it is usually the first point of contact between the community in rural areas and the primary healthcare system (Bashar & Goel, 2017). PHCs, which are led by Medical Officers (MO) are located in blocks, which are subdivisions of a district. Secondary care is delivered through Community Health Centers (CHCs) and sub-district hospitals. The CHCs are also located in blocks and they tend to be led by a Medical Officer-In-Charge (MOIC). Sub-district (or sub-divisional) hospitals tend to be more equipped than the CHCs but smaller than the district hospitals. Usually, they act as the First Referral Units (FRUs), providing specialty services such as emergency obstetric care. And finally, tertiary care is delivered through district hospitals and medical college hospitals. District hospitals provide specialized services while medical colleges provide medical education at the graduate and postgraduate levels (Bhatia, 2016; Chokshi et al., 2016).

Even though the Bhore committee envisioned an integrated health system, there continues to be inadequate public funding that allows the smooth functioning of such a system

(Peters et al., 2003a). Most health care expenses are paid directly out of pocket by patients and their families. In fact, Indian domestic general government health expenditure (as a percentage of current health expenditure) is merely 25.43%, lower than the average health expenditure of 32.2% for lower-middle-income countries (World Health Organization, 2016a). And current expenditure in health (as a % of GDP) is at 3.66%, also lower than the average health expenditure of 3.96% for the lower-middle-income countries (World Health Organization, 2016a).

Apart from lack of funding, the public sector suffers from other issues like lack of quality service, corruption, improper governance, lack of accountability, absenteeism, and neglect of patients leading them to bypass the public sector (Peters & Muraleedharan, 2008; K. D. Rao & Sheffel, 2018; K. S. Rao, 2017). The absence of a well-funded and robust public sector has led to the vacuum being filled by a large and unregulated private sector (Sengupta et al., 2017). The private sector—which encompasses large for-profit corporate hospitals, not-for-profit trusts, diagnostic laboratories, and qualified as well as unqualified general practitioners—provides almost 80% of the outpatient services and 60% of the inpatient services in India (Sengupta et al., 2017). Researchers have pointed to the negative impact of unregulated private provision of health care—unnecessary interventions, increase of out of pocket expenditure, and inequitable care (Morgan et al., 2016; Sengupta et al., 2017).

Apart from the challenges related to inadequate funding, there is the inherent problem associated with the power tussle between state and federal bodies. The constitution of India outlines the division of responsibilities in the health sector among the central, state, and local governments, with the state being ultimately responsible for the delivery of health services

(Constitution of India, 1949). With inadequate funding from the state bodies and their lack of ability to maintain and administer secondary and tertiary level facilities, they have become more dependent on the center for financial assistance to implement public health programs. The central government has increasingly received more financial and programmatic control, which had eroded the capacity, accountability, and ownership of the programs of the states (Misra, 2002; Peters et al., 2003a).

While these problems exist throughout India, they are particularly acute in UP. Despite facing some of the most acute health problems, it spends a mere INR 733 (10 USD) per capita on health, one of the lowest among the states in the country. Public expenditure on health as a percentage of GSDP is a mere 1.44%, lower than the national average (Ministry of Health & Family Welfare, 2018). Historically, UP has had issues with corruption and lack of accountability in the health system, to a point of murder of medical officers in broad daylight in relation to mismanagement of funds from the National Rural Health Mission (NRHM), a centrally sponsored health initiative (Chatterjee, 2012). UP also consistently ranks lowest, among all the states in terms of health sector performance, and between 2015/16 and 2017/18 actually showed a deterioration in progress (NITI Aayog et al., 2019). The phenomenon of the private sector providing a large amount of health care is also evident in Uttar Pradesh, where the majority of the deliveries happen in the private sector (Government of India, 2015). While UP has a pluralistic health system, most of the health services are provided through private providers, and the public system has been in dismal condition (Chakraborty, 2003).

1.3.2. Demographic and epidemiological profile of Uttar Pradesh

UP is located in the northern region of India (see Figure 3) and it is the most populated state with around 230 million inhabitants, almost 16% of the country's total (Ministry of Home Affairs, Government of India, 2011). Despite improvements in some health indicators in the past few decades, UP continues to have great needs to be addressed by public health. It remains one of the most economically disadvantaged states, with almost 30% of people living under poverty (The World Bank, 2016).

Figure 3. Map of India indicating the state of Uttar Pradesh

Even though India has made improvements in health outcomes in the past two decades, the difference in performance among states is stark. Table 2 shows the demographic

characteristics of UP, compared to its neighbor Bihar, to one of the highest performing states (Kerala) and national averages. UP has a relatively younger population with one-third (33.8%) of the inhabitants below 15 years of age. The total fertility rate is at 2.7, higher than the national average of 2.2. It is also deprived of some of the basic necessities like electricity, with almost a third of the households living without electricity. Just over one-third of the households have improved sanitary facilities, and only six percent of the household have any member covered by a health scheme or insurance. Only one-third of the births happen institutionally. Most of these institutional births take place in private facilities. While the rate of immunization among children aged 12-24 have seen secular upward trends in India, only about half of the children in the UP are fully immunized with BCG, measles, and three doses each of polio and DPT. Almost half of the children are stunted, and more than 60% of the children between 6-59 months of age are anemic. Women aged 15-49 who are anemic lies at a whopping 52%. Only 26.4% of the mothers had at least 4 antenatal care visits. More than 50% of the women aged 15 to 49 reported having their family planning needs unmet and over a third have ever experienced spousal violence. These numbers are a stark reminder of the enormous challenges associated with the health of the state.

Table 2. Demographic and health indicators of UP compared to the neighboring state (Bihar), high performing state (Kerala), and nationally

Indicators	**Uttar Pradesh**	**Bihar**	**Kerala**	**Nationally**
Population*	199,812,341	104,099,452	33,406,061	1,210,854,977
Population below age 15 years (%)	33.8	39.3	20.2	28.6
Sex ratio of the total population (females per 1,000 males)	995	1,062	1,049	991
Total fertility rate (children per woman)	2.7	3.4	1.6	2.2
Adult literacy rate (%)				
Female	61	49.6	97.9	68.4
Male	82.4	77.8	98.7	85.7
Infant mortality rate (IMR) (per 1,000 live births)	64	48	6	41
Under-five mortality rate (U5MR) (per 1,000 live births)	78	58	7	50
Maternal mortality ratio (MMR) (per 100000 live births)	201	165	46	130
Children under age 5 whose birth was registered (%)	60.2	60.7	97.7	79.7
Households with electricity (%)	70.9	58.6	99.2	88.2
Household with improved sanitary facility (%)[a]	35	25.2	98.1	48.4
Households with any usual member covered by a health scheme or health insurance (%)	6.1	12.3	47.7	28.7
Use of any family planning methods (%) (currently married women 15-49 years)	45.5	24.1	53.1	53.5
Unmet need for family planning (%) (currently married women age 15-49 years)[b]	18.1	21.2	13.7	12.9
Mothers who had at least 4 antenatal care visits (%)[c]	26.4	14.4	90.1	51.2
Mothers who received postnatal care from a doctor/nurse/LHV/ANM/midwife/other health personnel within 2 days of delivery (%)[c]	54	42.3	88.7	62.4
Children who received a health check after birth from a doctor/nurse/LHV/ANM/ midwife/other health personnel within 2 days of birth (%)[c]	24.4	10.8	49.1	24.3
Institutional births (%)[d]	67.8	63.8	99.8	78.9
Institutional births in public facility (%)[d]	44.5	47.6	38.3	52.1
Births assisted by a doctor/nurse/LHV/ANM/other health personnel (%)[d]	70.4	70	99.9	81.4

Indicators	Uttar Pradesh	Bihar	Kerala	Nationally
Children age 12-23 months fully immunized (BCG, measles, and 3 doses each of polio and DPT) (%)	51.1	61.7	82.1	62
Children under age 6 months exclusively breastfed (%)[e]	41.6	53.4	53.3	54.9
Children under 5 years who are stunted (height-for-age) (%)[f]	46.3	48.3	19.7	38.4
Children under 5 years who are wasted (weight-for-height) (%)[f]	17.9	20.8	15.7	21
Children age 6-59 months who are anemic (<11.0 g/dl) (%)[g]	63.2	63.5	35.7	58.6
All women age 15-49 years who are anemic (%)[g]	52.4	60.3	34.3	53.1
Ever-married women who have ever experienced spousal violence (age 15-49 years) (%)	36.7	43.2	14.3	31.1

Data:
National Family Health Survey (NHFS-4) (2015-16), Ministry of Health and Family Welfare, Government of India. Retrieved March 10, 2020, from http://rchiips.org/NFHS/NFHS-4Report.shtml;
* Office of the Registrar General and Census Commissioner (2011). Retrieved March 10, 2020, from http://www.census2011.co.in/states.php

a. Flush to a piped sewer system, flush to a septic tank, flush to pit latrine, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, which is not shared with any other household
b. Unmet need for family planning refers to fecund women who are not using contraception but who wish to postpone the next birth (spacing) or stop childbearing altogether (limiting)
c. For last birth in the 5 years before the survey
d. For births in the 5 years before the survey
e. Based on the youngest child living with the mother
f. Below -2 standard deviations, based on the WHO standard
g. Hemoglobin in grams per deciliter (g/dl). Among children, prevalence is adjusted for altitude. Among adults, prevalence is adjusted for altitude and smoking status

There may be multiple interconnected reasons for UP's poor performance, including acute shortages of health workers, high levels of corruption, a high turnover rate of managers at state and district levels, weak data systems, low functionality of health facilities, and scarce availability of health services, collectively leading to poor health outcomes. This collection of challenges probably requires a combination of solutions as a single intervention may be insufficient to drive positive system outcomes. The problems faced are connected in a complex fashion and solutions likely require health system changes and reforms that aim at long term change.

Given these myriad challenges as well as the state's size and importance in meeting Indian national and international public health targets, UP's health system has been a subject of many state-level and national health programs. The biggest central government-funded program is the National Health Mission, Uttar Pradesh (Patel et al., 2015). There are also many research studies conducted in the state to identify effective interventions to improve health outcomes. However, no data exists on the competencies of public health professionals who manage and supervise public health programs. There is a growing body of evidence to show that healthcare workers in low- and middle- income countries often provide poor quality of care (Das et al., 2012; Sylvia et al., 2015; Das et al., 2015; Daniels et al., 2017). While many studies have explored the relationship of such low performance on factors such as workplace conditions, motivation, level of remuneration, research on the relationship of competencies on performance remains limited.

1.3.3. Human resources in Uttar Pradesh

The discussion of competencies would be incomplete without a background in human resources for health. India has a shortage of health care workers (K. D. Rao et al., 2012; M. Rao et al., 2011). The problem is particularly acute in UP; there is only an estimated total of 9.1 health workers per 10,000 population (including both public and private sector employees) compared to the WHO proposed Sustainable Development Goal index threshold of 44.5 health workers per 10,000, and also below all India levels of 11.9 per 10,000 persons (World Health Organization, 2016b). Table 3 shows the density of key health workers in UP and India, with further stratification of UP's data to all private and public sector health workers currently registered in the UP Medical Council, public sector health workers that are sanctioned and contractual, and currently filled posts. As the table suggests, the shortage of health workers in the public sector is more severe than in the private sector. Over 75% of the healthcare providers work in the private sector, and the public sector is left with a mere 2.8 health workers per 10,000 persons.

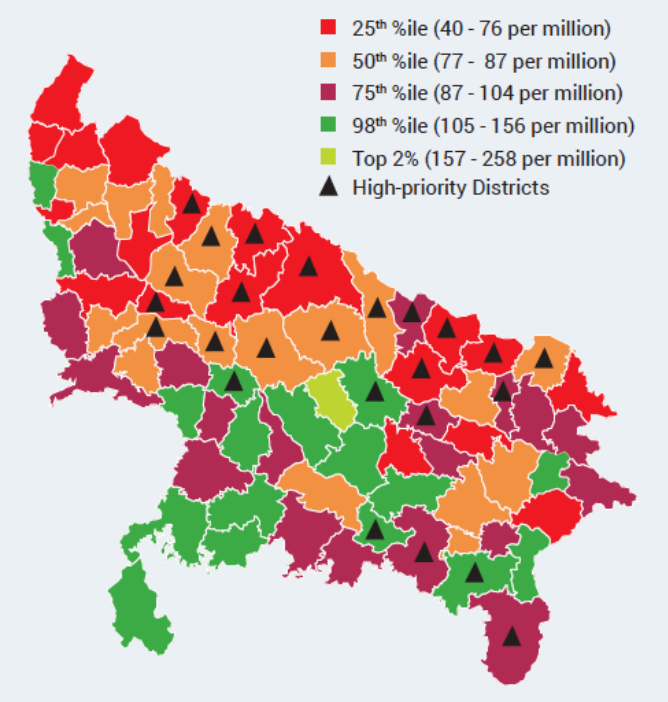
Table 3. Density of key health workers in UP and India (public and private)

	UP - All registered (Public & Private Sector)	**UP - Public Sector (Sanctioned & contractual)**	**UP - Public Sector (Currently Filled posts)**	**All India - Public & Private Sector**
Nurses & midwives per 10,000 population	5.8	3.3	2	~7.0-7.4[b]
All allopathic doctors per 10,000 population	3.1	1	0.8	~5.9-6.13[b]
All AYUSH doctors per 10,000 population	3.8	n.a.[c]	0.2	~1.7-2.63[b]
Nurses, midwives and doctors per 10,000 population	9.1	4.4	2.8	11.93[b]
Nurse to doctor ratio				
- Staff nurse: doctor	1.4:1	1:1	0.9:1	2.8:1[d]
- Nurses + Midwives: doctor	1.7:1	3.2:1	2.6:1	

[b] (K. D. Rao et al., 2016); [c]: Data for number of sanctioned posts for AYUSH doctors not available; [d] (Saikia, 2018). Table adapted from (Hariyani et al., 2019)

Within the state, there are vast inequities in the density of the health workers. Some of most rural districts also have the lowest density of health workers. Figure 4, developed by Hariyani and colleagues shows the variation in the density of general doctors across UP (Hariyani et al., 2019).

Figure 4. District-wise density of all public-sector general doctors per million persons (October 2018)



Note: High priority districts, indicated by the black triangle on the map, are determined by the Department of Health and Family Welfare for implementation of focused health care intervention under the National Rural Health Mission. These are identified as the bottom 25% of the districts in every state according to the ranking based on a composite health index. This index is created using District Level Household Surveys conducted by the Ministry of Health and Family Welfare. (Ministry of Health and Family Welfare, 2018)

The table and figure shown above are for health workers who mostly provide clinical services. Some of them may be expected to perform public health duties on top of their clinical services. For example, MOs need to take on responsibilities such as disease surveillance and public health program management as mentioned in their job description (Appendix 5). They also need to fulfill clerical and administrative tasks. The availability of health cadres that do not have clinical duties and hold public health responsibilities—for example, Block Program Managers (BPMs) and District Program Managers (DPMs)—are thought to be limited. However, reliable data to back this claim remains unavailable, as such estimation would be based on the state's human resource information management system called Manav Sampada. This

information system is rife with data quality issues, specifically reporting bias and missingness. Also, "availability" recorded in such a system may not accurately reflect the ground realities because a health worker who is reported to be "available" may not be physically present at their work. Absenteeism among health workers is considered to be rampant throughout the state, with data from 2004 showing almost 52% of doctors missing from work (World Bank, 2004).

Apart from the poor availability and distribution of health workers, UP also has problems with their performance management. There are few standards, training, and support mechanisms in place to strengthen public health worker performance in the public sector (McNatt et al., 2016; Peters et al., 2003b). These problems are particularly acute in the CHC and PHC-levels. The Chief Medical Officers (CMOs) and MOs charge currently lack the administrative and managerial skills to carry out the work, and there is an excessive reliance on desk clerks for important tasks. There are key gaps in core public health competencies for problem-solving, which need to be further identified and addressed in order to improve performance management.

1.3.4. Uttar Pradesh Health Systems Strengthening Support (UPHSSS) project and my role

To tackle some of these issues, Johns Hopkins Bloomberg School of Public Health (JHSPH) has been working closely with the Uttar Pradesh Technical Support Unit (UP-TSU)[b], University of Manitoba (UM), and the Government of Uttar Pradesh (GOUP) since November

[b] Uttar Pradesh Technical Support Unit (UP-TSU or TSU) is a techno-managerial agency that supports planning, managing, and assessing health interventions of GoUP.

2017 to support several new and ongoing health system strengthening efforts in the state. This research is conducted within the larger umbrella of JHPSH's Uttar Pradesh Health Systems Strengthening Support (UPHSSS) project. The research also responds to the short-term analytic demands of UP-TSU, the leadership of the GOUP, and the Gates Foundation. This support is collectively aimed at accelerating progress toward reducing maternal, neonatal and child morbidity and mortality and improving overall population-level health indicators in the state.

The support provided by JHSPH was initially conceived through extensive consultations with the leadership of the UP-TSU and UM and through discussions with key stakeholders from the Department of Medical Health and Family Welfare (DOMHFW) and the Bill and Melinda Gates Foundation. The health systems challenges in UP are systemic and deep-rooted. Against this context, the following areas were initially identified as priorities for addressing some of the underlying health systems issues in UP.

- Improving performance management: The medical officers at all levels currently lack the administrative and managerial skills to carry out the work and there is an excessive reliance on desk clerks for important tasks. There are also gaps in public health competencies that need to be identified and addressed in order to improve performance management.
- Strengthening human resource management: There exist problems with the distribution and patterns of deployment of the health workforce in UP. The GOUP has proposed several interventions to improve accountability, training, selection, deployment, and retention. However, many of these efforts do not build in lessons from elsewhere in India and other low-resource settings. In addition, the Health Resource Management Information System

(HRMIS) is not being used to inform decision making and there is little capacity within the government to do so.

- Enhance the use of data for decision-making: There are many inadequacies in data use and processes to use data among key stakeholders of the health sector. Policymakers and program leaders require training and data presented in appropriate formats to inform their planning and decision-making. There is low use of data by policy and decision-makers, but also little understanding of their potential demand for data, and how data can be used to better inform decision-making. Approaches and use of data to empower and strengthen accountability for communities and individuals are even more under-developed yet provide significant opportunities to improve health systems performance.

Apart from these workstreams, research related to documenting social accountability initiatives in the state, generating strategies to improve coordination and collaboration between different branches of the department, and improving the training capacity of the state is also ongoing as a part of UPHSSS.

The data used in this dissertation research is collected as a part of the UPHSSS project, and it falls within the performance management workstream. There is planned work on public health training of select health cadres based on the results of the competency assessment.

I started working on the UPHSSS project in March 2018 when I traveled to UP with Dr. David Peters (Principal Investigator of UPHSSS) for an initial scoping visit to meet stakeholders at the UPTSU, GoUP including the Secretary of Health, and external agencies like the Indian Institute of Management and Sanjay Gandhi Postgraduate Institute of Medical Sciences (SGPGI). These meetings refined the project's scope of work. After my initial visit, I contributed

to the work in the performance management workstream by developing a prototype for a Balanced Scorecard (BSC) for the state of UP and generating a research plan for data collection activities. From September till December of 2018, I lived and worked in Lucknow to lay the groundwork for data collection to start. This included activities like developing a Request for Proposal (RFP) for data collection agencies, reviewing bids, and selecting the appropriate agencies. In February 2019, I returned to UP from the US to acquire necessary government and in-country IRB approvals, conduct primary data collection, and conduct preliminary analyses of the collected data. In December of 2019, I returned to the US to complete the dissertation analysis and writing process.

2. Identifying core competencies for practicing public health professionals: results from a Delphi exercise in Uttar Pradesh, India (Paper 1)

2.1. Abstract

Ensuring the current public health workforce has appropriate competencies to fulfill essential public health functions is challenging in many low- and middle-income countries. The absence of an agreed set of core competencies to provide a basis for developing and assessing knowledge, skills, abilities, and attitudes contributes to this challenge. This study aims to identify the requisite core competencies for practicing health professionals in mid-level supervisory and program management roles to effectively perform their public health responsibilities in the resource-poor setting of Uttar Pradesh (UP), India.

We used a multi-step, interactive Delphi technique to develop an agreed set of public health competencies. A narrative review of core competency frameworks and key informant interviews with human resources for health experts in India as conducted to prepare an initial list of 40 competency statements in eight domains. We then organized a day-long workshop with 22 Indian public health experts and government officials, who added to and modified the initial list. A revised list of 54 competency statements was rated on a 5-point Likert scale. Aggregate statement scores were shared with the participants, who discussed the findings. Finally, the revised list was returned to participants for an additional round of ratings. The Wilcoxon matched-pairs signed-rank test was used to identify stability between steps, and consensus was defined using the percent agreement criterion.

Stability between the first and second Delphi scoring steps was reached in 46 of the 54 statements. By the end of the second Delphi scoring step, consensus was reached on 48 competency statements across eight domains: public health sciences, assessment and analysis,

policy and program management, financial management and budgeting, partnerships and collaboration, social and cultural determinants, communication, and leadership.

This study produced a consensus set of core competencies and domains in public health that can be used to assess the competencies of public health professionals and revise or develop new training programs to address desired competencies. Findings can also be used to support workforce development by informing competency-based job descriptions for recruitment and performance management in the Indian context, and potentially can be adapted for use in resource-poor settings globally.

Keywords: Public health competencies, Delphi technique, human resource development, India

2.2. Background

Core competencies are the key knowledge, skills, abilities, and attitudes that the health workforce should possess to effectively deliver essential public health functions such as disease prevention, health promotion, and preparedness for public health emergencies (Public Health Foundation, 2014; World Health Organization, 2018). A competent workforce is a prerequisite for a high performing public health system (World Health Organization, 2000, 2006; Willis-Shattuck et al., 2008; Peters et al., 2010). The Coronavirus disease 2019 (COVID-19) pandemic has highlighted the need for the public health systems and the human resources which staff such systems to possess competencies such as disease surveillance, risk communication, and leadership and management. However, many resource-poor settings struggle to ensure that the health workforce has the appropriate public health competencies needed to perform public health functions effectively (Frenk et al., 2010b; M. Rao et al., 2011).

Uttar Pradesh (UP) is the largest state in India, with almost 230 million people (Ministry of Home Affairs, Government of India, 2011). As with many states in the country and resource-poor settings globally, UP continues to face several health workforce challenges. There are currently an estimated 9.1 health workers per 10,000 population compared to the WHO's proposed Sustainable Development Goal index threshold of 44.5 health workers per 10,000 population (World Health Organization, 2016c). There are no requirements for health workers to receive public health training, making it challenging to deliver essential public health functions for population health or professionally manage health services. In addition, there remains a mismatch between available professional competencies and population health needs, an unsuitable mix of competencies among the health workforce, and the maldistribution

of professionals across geographical areas—specifically rural and urban areas (Global Health Workforce Alliance and WHO, 2008).

The identification of core competencies for public health professionals in UP provides a basis to address some of these challenges. Core competencies draw on multiple public health disciplines and are not specific to a single program or topic. Core competencies should be defined for all employees in all positions throughout the public health system. However, competencies may be required at different proficiency levels for different cadres depending on the nature of their job responsibilities.

Around the world, efforts to develop core competencies for public health professionals have largely been made in High-Income Countries (HICs) and regions (Foldspang et al., 2018; Public Health Agency of Canada, 2008; The Council on Linkages, 2014), for the clinical health workforce (Berendes et al., 2011; Das & Hammer, 2005d; World Health Organization, 2016d), researchers working in resource-poor settings (Alonge et al., 2019), and public health academic programs (Calhoun et al., 2002, 2008, 2012). In India, the Public Health Foundation of India (PHFI), the Union Ministry of Health and Family Welfare (MOHFW), and others have developed core competencies frameworks for Master's in Public Health (MPH) programs and community medicine fellowships (Ministry of Health and Family Welfare, Government of India, 2018; Raghav et al., 2016; Sharma et al., 2013). However, competency identification for professionals who are currently practicing public health in low- and middle- income countries (LMICs) is uncommon.

This study builds on these previous efforts and aims to identify the core competencies for public health professionals in supervisory or program management roles in UP. Currently,

the state has no designated public health cadre, so these competencies are intended for professionals who have job responsibilities pertaining to public health. The identified core competencies are applicable to staff like Medical Officers (MOs), District Program Managers (DPMs), and Additional Chief Medical Officer (ACMO) who are senior to the frontline outreach staff (i.e., ASHAs, Anganwadi workers) and junior to senior management and executive-level staff (i.e., Directors, Additional Directors, Chief Medical Officers) the UP health system. Examples of responsibilities include developing operational plans to implement national programs, providing assistance in the formulation of village health and sanitation plans, undertaking financial and administrative duties, and organizing in-service training programs for staff in their facilities.

This study was undertaken as a part of broader efforts to strengthen public health worker performance, performance management, and training in the state. These efforts, particularly public health training, are timely given the national emphasis on health promotion and prevention through the creation of Health and Wellness Centers (HWCs) under the Ayushman Bharat program (Ministry of Health and Family Welfare, Government of India, 2016). The Indian national health policy (2017) has encouraged states to create a separate public health cadre (Ministry of Health and Family Welfare, 2017). As UP contemplates developing its public health cadre, core competencies and subsequent training of current health officials can act as a stopgap measure to address current public health deficiencies. These can also inform the formal training that a public health cadre would need. Results can also be adapted for use in other resource-poor settings globally to develop competency-based management systems to

aid training, better job analysis, job design, and performance management of human resources for health.

2.3. Methods

We employed the multi-step interactive Delphi technique called Estimate-Talk-Feedback-Estimate (EFTE), a widely-used consensus generating method that solicits opinions of experts through a series of carefully designed questionnaires and face-to-face discussions (Nelms & Porter, 1985; Turoff & Linstone, 2002). We used the Delphi technique because of its various advantages including anonymity between participants—which minimizes group discussion biases; iteration with controlled feedback of group opinion—achieved through the use of successive questionnaires allowing participants to amend their views if they want; statistical aggregation of group response—which is shared with the participants, enabling them to see where their opinions lie relative to the group response; and expert input—ensuring that the participants are experts adequately informed in the topic (Goodman, 1987). In our study, we employed eight steps using the Delphi technique (Figure 5).

Figure 5. Step diagram of the process and results of identifying core competencies for public health professionals

1. **Generation of an initial list of relevant core competencies**

We prepared an initial list of 40 competency statements across eight public health domains after undergoing a narrative review and synthesis of core competency frameworks globally and rapid qualitative interviews with Indian public health experts (Appendix 9).

For the narrative review and synthesis, we examined the available core competency frameworks from Canada; Europe; New Zealand; Spain; United Kingdom; United States; and the Americas, which comprise both continents of North and South America (The Council on Linkages, 2014; Foldspang et al., 2018; Public Health England et al., 2019; Pan American Health Organization, 2013; Benavides et al., 2006; Public Health Association of New Zealand, 2007). Competencies listed for Indian MPH curriculums developed by PHFI and the MOHFW were also assessed (Ministry of Health and Family Welfare, Government of India, 2018; Sharma et al., 2013).

Rapid qualitative interviews were conducted with six Indian experts to identify context-specific core competencies to consider. Interviewees with knowledge and expertise in the competency identification of health workers and familiar with the UP context were purposively selected. Examples of the respondents include a senior director from the Government of UP (GOUP) overseeing the training of health workers; a professor based at a large medical institute in UP and with expertise in the development of human resources for health; and a representative of a multilateral organization and with extensive experience studying competencies among health workers. We used a semi-structured interview guide to extract themes related to participants' understanding of public health and essential public health functions, their comprehension about public health competencies, core competencies required

of mid-level public health workers to deliver these essential public health functions, and current challenges as well as opportunities to integrate core competencies in workforce development efforts. After this, we reviewed the transcripts of the interviews, determined sections relevant to the research question, inductively developed a coding system, and identified the material in the transcript related to each topic. We then reworked the competency statements to integrate the findings of the interviews.

2. Organization of a consensus workshop

We sought to arrive at a set of public health competencies through a consensus-building process that included a wide range of stakeholders, as this would likely increase the prospects of the results being used in workforce development. A one-day consensus generation workshop was held in Lucknow, UP, on 26 July 2019. A diverse group of 22 participants with backgrounds in public health, professional education, and human resources for health representing the GOUP, academia, and public health Non-Governmental Organizations (NGOs) in India participated in the meeting. A few examples of the participants involved are a director of a department in UP's directorate of medical and health, an additional director from one of UP's lower administrative divisions, dean of training from a large research university outside UP, a professor of public health with an expertise in human resource development, and a representative from an international public health organization. Table 4 provides the demographic characteristics of the participants.

Table 4. Demographic characteristics of the Delphi participants (N = 22)

		Number	Percentage
Gender	Male	19	86%
	Female	3	14%
Current role	Academic	6	27%
	State trainer[a]	4	18%
	Senior manager in government	9	41%
	Other (e.g., public health NGO)	3	14%
Professional location	Within Uttar Pradesh	16	72%
	Outside of Uttar Pradesh	6	28%

[a] State trainer is a faculty member of the State Institute of Health and Family Welfare. One of their primary responsibilities is to train the newly inducted Medical Officers in the public system on public health topics.

At the beginning of the Delphi process in the workshop, the principal investigator of this study provided detailed background information to the participants about core competencies and the Delphi process to be used in making opinion judgments, and he resolved any questions that participants had.

3. Revision and addition to the initial list

The 22 participants were divided into four separate groups, with approximately 6 participants per group. These groups were determined before the workshop to ensure heterogeneity of backgrounds among participants in each group.

A list of the initial 40 draft competencies (prepared in step 1) was given to each participant, who then modified and added to the list individually. Participants were asked to focus on amending the list in light of the critical competencies that they thought were necessary to work successfully as a public health program manager or supervisor in UP. Specifically, we encouraged the participants who were considering adding a new statement to reflect on whether their addition would include something different from what was already on the list. For those considering a potential revision, we encouraged them to avoid revisions that

would fundamentally alter how a competency was understood and focus instead on content clarification rather than wordsmithing (e.g, changing style). In their groups, participants then discussed major changes and additions to the competency list. However, discussion regarding weights or importance of competency statements was discouraged to avoid groupthink and interfere with the goals of the process.

4. **Compilation of amendments, and development of a modified list**

The Delphi facilitators in each group (each with graduate training in public health, who were provided training specific to Delphi facilitation) consolidated the written amendments from the participants to decrease duplication and sought clarifications on competency phrasing if required. The facilitators then worked across groups to compile the list of additions and modifications to develop an updated competency list, which included 54 competency statements.

5. **First Delphi scoring**

This modified list of competency statements was presented to all 22 participants. They individually rated each of the 54 competency statements in terms of their importance on a five-point Likert scale, from 1 as “not at all important” to 5 as "absolutely essential." Participants then scored each statement on its own merit instead of comparing it against the other proposed competencies. They were encouraged to score based on how important they thought the competency is to provide public health services as a mid-level public health manager in UP currently.

6. **Score compilation, analysis, and summarization**

The questionnaire results from step 5 were compiled, analyzed, and summarized. Results were shared with individual groups and displayed to the panel. Competency statements were ranked from high (absolutely essential) to low (not at all important). Averages, median, and quartiles were shared with the participants to facilitate the discussion.

7. **Discussion of results**

Participants discussed the results of at least two domains pre-assigned to their groups. Delphi facilitators guided the discussions, and participants were allowed to question findings and suggest alternatives. We allowed suggestions to upgrade the lowest-rated competencies, downgrade the highest rated competencies, or change ratings for other competencies. Suggestions on changing the wording of competencies could be written on papers to be considered, but we encouraged the participants to not make that the focus of the discussion. Any conflict was resolved through discussion—clarifying the disagreement, reiterating the objectives of the whole exercise, brainstorming alternative options, and agreeing on a solution. Each group then reported back to the plenary on the main points from their discussions.

8. **Second Delphi scoring**

The same competency list was returned to the 19 remaining participants who were asked to rate these statements again. This step had three fewer participants compared to the previous step as they had left the workshop due to unforeseen commitments. All three participants who left were male, two of whom were government human resource planners, and one was an academic. The workshop concluded after this step.

Data analysis

After the workshop, the stability between Delphi scoring steps (steps 5 and 8 listed above) was assessed using Wilcoxon matched-pairs signed-rank test. Previous research shows that it is necessary to ensure that there is enough stability between Delphi scoring rounds to establish that the results are stable and reliable (Trevelyan & Robinson, 2015). A statement was considered stable if there was no statistically significant change in responses between the scoring steps for each statement ($p \geq 0.05$).

Consensus was identified using the percent agreement criterion. A statement was deemed to have reached consensus when over 80% of the participants ranked it as "very important=4" or "absolutely essential=5" in the second Delphi scoring step (step 8).

Data from the two Delphi scoring steps were entered into STATA 14.2 and analyzed (StataCorp, 2016). For both the scoring steps, the measures of central tendency (mean, median, and mode) and measures of dispersion (range, interquartile range, and standard deviation) were also calculated.

2.4. Results

A. Findings from the narrative review: International scenario of core competencies for public health professionals

Based on the narrative review, we found similarities in domains and competencies across various core competency frameworks, as well as differences in their emphasis (Appendix 8). Most of the frameworks highlight the importance of utilizing public health assessment and analysis tools, using communication competencies to improve health outcomes and reduce

health inequalities, and translating public health sciences into practice. However, there are also variations and different emphases. For example, New Zealand uniquely specifies competencies related to the knowledge, understanding, and use of culturally appropriate approaches while working with their indigenous population of Maori (Public Health Association of New Zealand, 2007). On the other hand, the European framework outlines the competency related to the knowledge and understanding of the genetic factors that affect health outcomes following exposure to environmental hazards (Foldspang et al., 2018).

In reviewing the similarities and differences across the frameworks, we merged domains and competencies that were similar and selected dissimilar ones that we deemed valuable in the UP context to be considered by the Delphi participants. We also reviewed Indian MPH core competency frameworks that have been proposed by PHFI and MOHFW, which identify 86 and 20 core competencies, respectively.

B. Findings from the Key Informant Interviews

Respondents underscored the importance of a variety of competencies, including those related to management. They discussed the significance of financial and human resource management, including the active supervision of teams. Given its importance, we separated management in two domains in the initial competency list—one that focused on policy and program management and the other on financial management and budgeting. Assessment and analysis skills were also highlighted as important competency areas. Respondents emphasized skills in computing and situation analysis of environmental factors like floods and epidemics, which impact the functioning of the health units. They also discussed communication as another critical competency, which relates to the ability of health workers to use interpersonal

skills while working with the community and patients. Findings on these areas were incorporated in the initial list of competencies by either expanding on or retaining competency items from the analytical and assessment, and communication domains.

The initial list of domains and competencies prepared after the narrative review and key informant interviews is in Appendix 9. This list had 40 competencies across eight domains—public health sciences, assessment and analysis, policy and program management, financial management and budgeting, partnerships and collaboration, social and cultural determinants, communication, and leadership. The public health sciences domain focused on competencies to apply the science of disciplines such as biostatistics, epidemiology, and demography to practice. Assessment and analysis focused on competencies to make data-driven decisions and provide recommendations for policy and program development based on evidence. Policy and program management described competencies necessary to plan, implement, and evaluation of public health policies as well as programs. Financial management and budgeting domain included competencies required to use a variety of sources and mechanisms of funding to deliver public health programs and services. Partnerships and collaboration domain included competencies needed to identify and collaborate with different stakeholders. Social and cultural determinants involved competencies needed to interact effectively with individuals, groups, and communities that have diverse socio-economic and cultural backgrounds. Communication domain focused on competencies needed for the exchange of ideas and opinions as well as the use of technology for advocacy. And lastly, the leadership domain included core competencies needed to enable groups of people, organizations, and communities to communicate and apply shared visions and missions of an organization.

C. Findings from the Delphi workshop

Several changes were proposed in step 3—revision and addition to the initial list. Fourteen new competencies were added. See Table 2 for these additions and amendments, which formed the subsequent competency list that participants rated in the Delphi scoring rounds.

Public health sciences domain saw two new competencies added—one on the ability to demonstrate action related to community need assessment, and the other on applying knowledge of public health tools and techniques. In the assessment and analysis domain, a competency statement on the assessment of the accuracy and importance of data for public health decision making was added. The policy and program management domain saw the addition of five new competencies: on the ability to undertake supply chain and logistics management, demonstration of awareness and coordination skills of policies across different sectors, supporting learning within the organization, leveraging technology to innovate and improvise, and the ability to manage time appropriately. The financial management and budgeting domain had one addition related to the use of financial and accounting techniques for budgeting, procurement, staffing, accounting, and expenditure tracking. Participants added two new competencies in the partnerships and collaboration domain—one on determining benefits of the partnership with different actors and another related to being able to listen, engage, and mobilize communities. Participants added three new competencies—knowledge about leadership styles, identifying the need for change and managing such change, and maintaining organizational justice as well as fairness in dealing with subordinates—in the leadership domain.

Stability between the two steps of Delphi scoring was reached in 46 of the 54 statements presented to the participants. Eight statements where stability was not reached ($p<0.05$) are identified with a red highlight in the corresponding p-value. Given their importance—determined by percent agreement criterion—we included seven of them on our final list. The remaining one item did not meet the consensus agreement criterion and was removed from the final list. By the end of the third round, consensus was reached on 48 competency statements across eight domains: (1) public health sciences, (2) assessment and analysis, (3) policy and program management, (4) financial management and budgeting, (5) partnerships and collaboration, (6) social and cultural determinants, (7) communication, and (8) leadership. Six items that did not reach consensus were removed from the final list. Results from the Delphi scoring steps, including the median and proportion consensus for each competency statement, are summarized in Table 5.

2.5. Discussion

We generated expert consensus on core competencies for public health professionals assuming mid-level management roles in Uttar Pradesh, India, using an interactive Delphi technique. Consensus was achieved on 48 competencies across eight domains in public health. These competencies represent the current requirements of health professionals to fulfill their job roles and to address the public health needs of UP.

To our knowledge, this is the first attempt to develop core competencies for practicing public health professionals in a resource-poor setting like UP, India. There have been previous efforts in India and other LMICs to generate core competencies in public health education.

However, an attempt to identify practice-related competencies is novel. It is helpful to recognize the distinction between core competencies for public health professionals and those for students in educational programs. Educational competencies tend to delineate the skills, knowledge, abilities, and attitudes that students are expected to achieve at the end of their academic programs. They may be organized around traditional academic disciplines like biostatistics, epidemiology, health policy and management, environmental health, and social and behavioral sciences. Professional competencies, on the other hand, reflect the current needs of the workforce, and these are considered to be at the foundation of individual and team success in the workplace (Gosselin et al., 2013). The two are related, and typically the workplace competencies should inform the educational competencies that prepare students for the workplace.

The core competency framework developed in this study covers many of the competencies and domains identified in HICs. However, it also differs in its emphasis on policy and program management, as evident by the number and variety of competencies in this domain. Frameworks from HICs tend to emphasize analysis, assessment, and public health sciences. This difference may reflect the focus of the roles that public health professionals are expected to fulfill in resource-poor settings like UP. Given health systems challenges like lack of access to essential services, overcrowding of clinics, and medicine shortages, there might be an expectation of public health professionals to possess competencies to manage programs in a resource-constrained environment. This distinction may also reflect the weaknesses of health systems in resource-poor settings, and the greater need to train public health professionals in management—a vital lever to strengthening health systems (Bradley et al., 2015).

There were six competencies—which belonged to public health sciences, assessment and analysis, policy and program management, partnerships and collaboration, and leadership domains—that did not achieve consensus in the second Delphi round and were removed from the final list. The removed statements are similar in that they focus on demonstrating knowledge rather than skills and their application, on which many of the statements that achieved consensus focused. For example, statements related to demonstrating knowledge about the history and structure of health services, determining the meaning of information, demonstrating awareness of policies, and demonstrating knowledge about leadership styles did not reach consensus. Such lack of consensus could be attributed to the fact that the final list of competencies is meant for practitioners who are expected to apply competencies in their jobs, rather than possess knowledge alone. On the other hand, the final list of competencies could have risen to the top because they represent the skills, knowledge, abilities, and attitudes necessary or expected of public health professionals in UP.

There were eight statements in our that did not meet the stability criterion. Of these eight statements, only one was removed from the final list because that one statement did not meet the percent agreement criterion. We left the other seven "unstable" statements in the final list of competencies because they were deemed important, i.e., they met the percent agreement criterion which relies on Likert scale scoring. To explain this logic, it might be helpful to think of stability and percent agreement criteria in terms of a hierarchy, as demonstrated in Appendix 10. Stability comes first and then the percent agreement criterion—in other words, Delphi organizers would try to gain stability in all the statements, then move on to the percent agreement criterion to evaluate consensus and terminate the study (Dajani et al., 1979; von der

Gracht, 2012). If there were statements that were found to be unstable between say, the first and the second round, then the Delphi process would proceed to another round of scoring, a third round. This process would continue until all statements met the stability criterion. Once the stability of all items was confirmed, consensus measurement (using method such as percent agreement criterion) would be conducted to find which items did or did not make the final list.

For this study, ideally, we would have continued with the Delphi rounds until we found stability in all statements, including the eight that did not meet our stability threshold at the end of the second round. However, we were constrained by time, so we had to limit ourselves to only two scoring rounds. This meant that we had to consider all statements as stable in order to even use the percent agreement criterion to identify consensus. If we had not made this decision, we would be left in an immovable spot, where we were neither able to conduct additional scoring round (for time reasons) nor run the percent agreement analysis (for the theoretical need to go through an additional round). This "immovable" situation is not uncommon in Delphi studies, and as Gracht (2012) acknowledges, "a certain level of agreement, e.g. convergence of opinions toward consensus, may in turn also be found in an unstable situation" (von der Gracht, 2012). We chose to conduct and also report both stability and percent agreement analyses for this paper to comply with the emerging scientific norm to test and communicate both stability as well as the level of consensus rather than just consensus (Chaffin & Talley, 1980; Dajani et al., 1979; Nelson, 2000; Scheibe et al., 2002; von der Gracht, 2012).

During our study, we identified an important theoretical gap related to the core competency development process that may be relevant to researchers elsewhere. During the

study, we had grapple with two opposing demands—our framework had to be broad enough to be comprehensive for all mid-level professionals, but it also targeted enough to be relevant for each and every one of those professionals. However, the public health sector in the mid-level includes many different positions with various responsibilities and expectations. It involves anywhere from an MO who is usually in charge of primary health care centers at the block level to District Program Managers (DPMs) who work in the district health office and are in charge of public health programs for the entire district. The breadth is so wide, there was confusion as to who the target audience of the framework should be.

Researchers elsewhere might face a similar dilemma. So, we propose two major ways to address this issue. The first relates to how we envision the core competency framework to be used. Core competencies are meant to include foundational or crosscutting skills for all individuals working in public health at a particular level. The onus should fall on the user—policymaker or educator—of the framework to understand the importance of individual core competency to a specific position as they may vary depending on the position. The user should evaluate the types of positions and career trajectories when planning competency-based professional development to ensure that an organization collectively has the strengths across these competencies. So, the framework should not be considered set in stone, but rather a flexible document that end-users can utilize to address their specific needs.

The second way to address this issue could be by identifying functional competencies. While core competencies broadly define the knowledge, skills, abilities, and attitudes for all health professionals regardless of their discipline in a health system, functional competencies are discipline-specific and can build on core competencies. Functional competencies can be

developed for groups of professionals like epidemiologists, public health nurses, and public health informaticians.

This study has three significant limitations. The first limitation relates to the starting point for core competencies *vis-à-vis* essential public health functions or job descriptions. In UP, there is no consensus set of Essential Public Health Functions (EPHFs). Core competencies should map to these EPHFs, which is a set of services that underline the activities that public health workers should perform. In the absence of delineated EPHFs, one could use health workers' job descriptions as the starting point for core competencies. However, there were challenges associated even with job descriptions. Job descriptions for some mid-level health professionals are either non-existent (e.g., Deputy Chief Medical Officer, district public health nursing officer) or too generic. Also, there might be a high degree of task variation for the same position across the state. So, we depended on the Delphi participants' expertise to define and interpret health workers' responsibilities.

The second limitation relates to the use of the Delphi technique, which has numerous variations in how it is operationalized. Such variations have left the technique open to methodological interpretations and criticisms. For this study, the cutoff point of 80%, stability criteria, and the composition of the expert panel were particularly relevant. In terms of the cutoff point, 80% or higher was chosen *a priori* because this threshold is common in many Delphi studies (Diamond et al., 2014). However, the theoretical basis for such cutoff is unexplored (Powell, 2003). In terms of analysis, there were a few statements that did not meet the stability criteria, as indicated in Table 5. It is possible that subsequent Delphi scoring steps may have generated the stability in these statements as well.

Regarding the composition of the expert panel, panelists for this study were chosen after extensive consultations and online searches. However, some potential participants declined the invitation due to a lack of availability. These non-participants were similar in their backgrounds from the participants in the Delphi process. However, a different composition of Delphi participants may have resulted in a different final set of competency statements, as experts panels largely dictate the nature and content of the results in Delphi studies (Goodman, 1987).

The third limitation relates to the duplication of a few items in the final list of competencies. We found that some items conceptually overlapped with other items on the list. For example, the statement on recommending specific action based on the analysis of information (under assessment and analysis domain) was found to be almost identical to other statements such as using evidence and research to inform health policies and programs (under public health sciences domain) and using evaluation and data to improve health systems, programs, and organizational performance (under the policy and program management domain). This limitation could be addressed through the consolidation of these duplicate items while retaining all the concepts. Such consolidation was conducted in Paper #2 of this dissertation.

2.6. Conclusion

This article describes the development of core competencies that can be used in a number of specific ways in UP and other resource-poor settings globally, where these competencies may be adapted for local use. First, core competencies can be codified through

government orders to help link future efforts in performance management to these competencies. Second, the results of this study can be used to develop a competency assessment instrument. Future research can assess the reliability and validity of that instrument, which can then be used to evaluate levels of competencies of health professionals working in public health management and supervisory roles (Veras et al., 2012). The results of the assessment can inform appropriate in-service training programs to address gaps in competencies. Third, these results can be used to evaluate training programs offered through the state and academic institutes to ascertain their ability to meet the competencies expected of public health professionals. Based on the findings of the training evaluations, we can improve training programs by collaborating with relevant stakeholders. This may entail a revision of the training modules through consultation with curriculum designers and trainers, and the development of cadre-specific training modules. Fourth, the findings can be used to map the core competencies against the current job descriptions of various health cadres to identify gaps across domains in knowledge, skills, abilities, and attitudes. The results of the mapping process can be used to amend the job descriptions and make them competency-based. Competency-based job descriptions will assist in recruitment efforts like screening and interviewing, and to define Key Results Areas (KRAs) that enable fair and effective performance management systems. And last, the results provide a unique starting point for the development of a competency-based management system that can be used for workforce planning, recruitment, and development, as well as performance management of public health professionals.

Table 5. Results from the Delphi scoring steps

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
1. Public health sciences	**1.01 Demonstrate knowledge about the following concepts: the health status of populations, inequities in health, the determinants of health and illness, strategies for health promotion, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.**	22	5	95.45	19	5	100.00	0.15
	1.02 Demonstrate knowledge about the history, structure, and interaction of public health and health care services at local, district, state, national, and international levels.	22	4	54.55	19	4	78.95	0.03
	1.03 Apply the public health sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice including relationships between health and poverty and other forms of disadvantage.	22	4	77.27	19	4	100.00	0.11
	1.04 Use evidence and research to inform health policies and programs.	22	4	68.18	19	4	84.21	0.05

[3] **Bolded** statements compose the final list of competencies.

[4] Stability between Delphi scoring steps was assessed using Wilcoxon matched-pairs signed-rank test. We considered a statement to be stable if there was no statistically significant change in responses between the scoring steps for each statement ($p \geq 0.05$). Statements where stability was not reached ($p < 0.05$) have also been identified in red text in the table above. Given the importance of these competencies, we left them on our final list. We recognize that subsequent Delphi steps to generate stability in these statements would have been ideal.

[5] Step 8 (second round of Delphi scoring) had three fewer participants compared to Step 5 (first round of scoring). All three participants who left were male, two of whom were government human resource planner, and one was an academic. Note: participants are the same people in each step, as no new participants were added between steps.

[6] Consensus was identified using percent agreement criterion. A statement was deemed to have reached consensus when over 80% of the participants ranked it as "very important=4" or "absolutely essential=5" in the second Delphi scoring step. The statements where no consensus was reached have been identified in the table above with a red text in the corresponding p-value.

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
	1.05 Demonstrate fundamental action to undertake community need assessment. *	22	4.5	86.36	19	4	89.47	0.97
	1.06 Apply knowledge of public health tools and technique.*	22	4.5	86.36	19	5	84.21	0.65
2. Assessment and Analysis	**2.01 Identify relevant and appropriate sources of information, including community resources.**	22	4	90.91	19	5	100.00	0.03
	2.02 Collect, store, retrieve, and use accurate and appropriate data on public health issues.	22	5	72.73	19	5	84.21	0.03
	2.03 Analyze information to determine appropriate implications, uses, gaps, and limitations.	22	5	81.82	19	5	89.47	0.26
	2.04 Determine the meaning of information, considering the current ethical, political, scientific, socio-cultural and, economic contexts.	22	4	72.73	19	4	78.95	0.91
	2.05 Recommend specific actions based on the analysis of information.	21	5	90.48	19	5	94.74	0.09
	2.06 Assess the accuracy and importance of data for public health decision making.*	22	5	100.00	19	5	100.00	0.10
3. Policy and Program Management	**3.01 Describe selected policy and program options to address a specific public health issue.**	22	4	72.73	19	5	94.74	0.09
	3.02 Describe the implications of each option, especially as they apply to the determinants of health, and recommend or decide on a course of action.	22	4	77.27	19	4	84.21	0.56
	3.03 Develop a plan to implement a course of action, taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).	22	5	95.45	19	5	100.00	0.93
	3.04 Take appropriate action to address a specific public health issue.	21	5	100.00	19	5	94.74	0.48

*Competency statement was added in step 3—revision and addition of the list.

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
	3.05 Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses, etc.), including the allocation of personnel, financial, and other resources.	22	5	100.00	19	5	100.00	0.18
	3.06 Monitor and evaluate an action, policy, or program.	22	5	100.00	19	5	100.00	0.74
	3.07 Demonstrate the ability to fulfill functional roles in response to a public health emergency.	22	4.5	81.82	19	4	94.74	0.68
	3.08 Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining the scope of work and timeline).	22	4.5	95.45	19	5	94.74	0.93
	3.09 Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).	22	5	95.45	19	5	94.74	0.67
	3.10 Use evaluation and data to improve health systems, programs, and organizational performance.	22	5	86.36	19	5	100.00	0.50
	3.11 Undertake supply chain and logistics management, including inventory control.*	22	4	77.27	19	4	78.95	0.67
	3.12 Demonstrate awareness of policies across different sectors and coordinate across sectors.*	21	4	71.43	19	4	78.95	0.62
	3.13 Support learning within an organization including on-the-job learning.*	22	4	77.27	19	4	89.47	0.03
	3.14 Leverage technology to innovate, understand, apply, and evaluate/improvise.*	22	4	68.18	19	5	89.47	0.06
	3.15 Be able to manage time appropriately.*	22	4	81.82	19	5	84.21	0.29
	4.01 Justify programs for inclusion in budgets, develop and defends budgets.	22	4.5	81.82	19	5	89.47	0.31

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
4. Financial Management and Budgeting	**4.02 Prepare proposals for funding (e.g., foundations, government agencies, corporations).**	22	4	72.73	19	4	84.21	0.49
	4.03 Use financial analysis methods in making decisions about policies, programs, and services (e.g., economic analyses).	22	4	90.91	19	5	84.21	0.32
	4.04 Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).	22	4.5	95.45	19	5	100.00	0.14
	4.05 Use financial and accounting techniques for budgeting, procurement, staffing, accounting, and expenditure tracking.*	22	5	95.45	19	5	100.00	0.24
5. Partnerships and Collaboration	**5.01 Identify and collaborate with partners in addressing public health issues.**	21	4	85.71	19	5	94.74	0.65
	5.02 Use skills such as team building, negotiation, conflict management, and group facilitation to build partnerships.	21	5	95.24	19	5	94.74	0.91
	5.03 Mediate between differing interests in the pursuit of health and well-being ("and facilitate the allocation of resources"—deleted in second Delphi scoring).	22	4	68.18	19	4	84.21	0.10
	5.04 Determine benefits of the partnership with different actors to make strategic partnership choices.*	22	4	72.73	19	4	73.68	0.63
	5.05 Be able to listen, engage, and mobilize communities.* Error! Bookmark not defined.	20	4	75.00	19	4	89.47	0.32
6. Social and Cultural Determinants	**6.01 Recognize how the determinants of health (biological, social, cultural, economic, and physical) influence the health and well-being of specific population groups.**	22	4	81.82	19	5	94.74	0.19

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
	6.02 Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.	22	4	90.91	19	5	89.47	0.07
	6.03 Apply culturally-relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status, sexual orientations, and abilities.	22	4	86.36	19	4	89.47	0.29
7. Communication	**7.01 Listen and communicate effectively with individuals, families, groups, communities, and colleagues, including supervisors and team members.**	22	5	100.00	19	5	100.00	0.16
	7.02 Interpret information for professional, nonprofessional, and community audiences.	22	4	81.82	19	5	89.47	0.03
	7.03 Mobilize individuals and communities by using appropriate media, community resources, and social marketing techniques.	22	4	86.36	19	4	94.74	0.26
	7.04 Use current technology to communicate effectively.	22	4	100.00	19	5	94.74	0.39
	7.05 Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.	22	4	81.82	19	4	89.47	0.45
8. Leadership	**8.01 Describe the mission and priorities of the public health organization where one works and apply them in practice.**	22	4	81.82	19	5	100.00	0.01
	8.02 Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.	22	4	86.36	19	5	100.00	0.04
	8.03 Utilize public health ethics to manage self, others, information, and resources.	22	4.5	81.82	19	5	94.74	0.02
	8.04 Contribute to team and organizational learning in order to advance public health goals.	21	4	90.48	19	5	100.00	0.47

Domain	List of competencies[3]	First Delphi scoring			Second Delphi scoring			Stability: (p-value)[4]
		N	Median	% Consensus (>3)	N[5]	Median	% Consensus[6] (>3)	
	8.05 Contribute to maintaining organizational performance standards.	22	4	90.91	19	4	100.00	0.56
	8.06 Demonstrate an ability to build community capacity by sharing knowledge, tools, expertise, and experience.	22	4	77.27	19	5	94.74	0.11
	8.07 Demonstrate knowledge about different leadership styles, traits, etc.*	22	4	72.73	19	4	68.42	0.65
	8.08 Identify a need for change, manage change and processes.*	22	4.5	72.73	19	4	94.74	0.55
	8.09 Maintain organizational justice, equality, and fairness in dealing with subordinates.*	22	5	77.27	18	5	100.00	0.60

3. Development and validation of a tool to assess core competencies of public health professionals in low-income settings: findings from Uttar Pradesh, India (Paper 2)

3.1. Abstract

Achieving Universal Health Coverage (UHC) requires strengthening the core competencies of public health professionals. However, in many low- and middle- income countries, there is a lack of instruments to measure gaps in public health competency of health professionals. This study develops a validated and reliable Core Public Health Competency (COPHEC) index to assess the knowledge, skills, abilities, and attitudes of senior and mid-level public health professionals with supervisory and management responsibilities in Uttar Pradesh (UP), India.

Using the Core Competency framework that was developed in UP, we generated a draft COPHEC tool with 37 items, measured on a four-point Likert scale. We administered the tool to a total of 166 public health professionals that included two samples—84 senior and 82 mid-level public health professionals. To extract factors and assign factor scores to the instrument, we performed an exploratory factor analysis (EFA) using principal component analysis (PCA). Of the three measures of validity used for the study, construct validity was measured by assessing the average factor loading of the items onto the component extracted from EFA. Content and face validities were assessed by examining the steps used for the construction of the initial tool. Internal consistency was used as a measure of reliability.

The final COPHEC index with 37 items loaded on one factor in the sample. Content and face validities were assured because the initial set of items for the tool was adapted from the Core Competency framework, which was validated in the UP context. Construct validity of the COPHEC scale was confirmed by high average factor loading of components ranging from 0.60 to 0.81. The final index showed adequate reliability with Cronbach's alpha (α) = 0.97.

The COPHEC index is a valid and reliable measure of core competencies in public health in UP. We recommend that governments adapt the index in low- and middle-income countries to conduct assessments of health workers to identify training needs, evaluate the effectiveness of training programs through participants' competency acquisition pre- and post-training, and inform workforce development efforts in recruitment and performance management. Other researchers could conduct exploratory and confirmatory factor analysis in different geographic areas to revise and validate the instrument in their settings.

Keywords: Core Public Health Competencies (COPHEC), index, psychometric evaluation, factor analysis, human resource development, India

3.2. Background

Achieving Universal Health Coverage (UHC) requires that health professionals with public health responsibilities have the adequate knowledge, skills, abilities, and attitudes to deliver essential public health services (World Health Organization, 2000, 2006, 2016b; Willis-Shattuck et al., 2008; Peters et al., 2010; Frenk et al., 2010a). Core competencies are the critical knowledge, skills, abilities, and attitudes that the health workforce should possess to effectively deliver essential public health functions like epidemiological surveillance, situation assessments, and health promotion (Public Health Foundation, 2014; World Health Organization, 2018). They draw on multiple public health disciplines and are not specific to a single program or topic.

However, many low-resource settings, including the state of Uttar Pradesh (UP) in India, struggle to ensure that the health workforce has the appropriate competencies needed to effectively perform public health functions (K. D. Rao et al., 2012; M. Rao et al., 2011).

UP is the most populous state in India, with almost 230 million people (Ministry of Home Affairs, Government of India, 2011). As with many states in the country, UP continues to face several health workforce challenges. There are currently an estimated 9.1 health workers per 10,000 population compared to the WHO proposed Sustainable Development Goal index threshold of 44.5 health workers per 10,000 (World Health Organization, 2016c). There are no requirements and little opportunities for health workers to receive public health training, making it challenging to deliver essential public health functions (EPHFs) for population health or professionally manage health services. Also, there are discrepancies between professional competencies and population health priorities, an unsuitable mix of competencies among the

health workforce, and a maldistribution of professionals across geographical areas—specifically rural and urban regions (Global Health Workforce Alliance and WHO, 2008; M. Rao et al., 2011).

Two efforts can help address some of these challenges: (i) identification of the list of core competencies for public health professionals and (ii) assessment of the gaps in those competencies.

There has been much discussion about competencies in the public sector and academia in India. For instance, the Department of Personnel and Training of the Government of India, in collaboration with the United Nations Development Program (UNDP), started a competency-based system of strategic human resource management for the Indian Civil Service in 2011 (V. Gupta et al., 2018). The outcome of this effort was a "Competency Dictionary" that identified 25 core competencies across various roles and positions of the civil service employees (Government of India & UNDP, 2014). Related to this effort is the National Training Policy of 2012, which highlighted the importance of competencies, asserting that career progression and recruitment in public health jobs should be based on individual's competencies required for those posts (Government of India, 2012b). Similarly, the Indian national health policy of 2017 discusses the role of competency-based courses as a way to develop the cadre of mid-level primary care providers (Government of India, 2017). The Ministry of Health and Family Affairs (MoHFW) and other researchers have developed frameworks to define core public health competencies for Masters of Public Health (MPH) programs in India (Ministry of Health and Family Welfare, Government of India, 2018; Sharma et al., 2013).

Our recent study built on these critical efforts to identify the requisite core competencies for health professionals in mid-level supervisory and program management roles

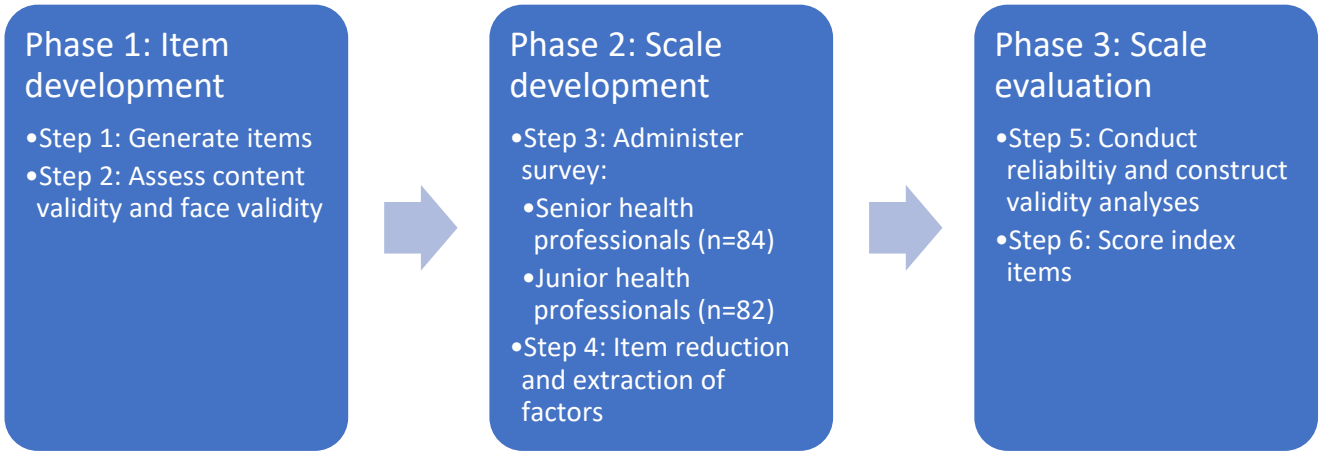
in UP (Paper #1 of the dissertation). However, there is still a need for validated and reliable tools to measure competencies among public health professionals. Most of the available metrics related to human resources for health (HRH) in low- and middle-income countries focus on availability, production, and distribution of health workers (Hall, 2001; Hazarika, 2013; World Health Organization, 2002). The limited number of tools that do focus on competencies are directed mostly for clinical health workers like medical doctors and nurses (Berendes et al., 2011; Das & Hammer, 2005d). Even these instruments tend to focus on selective areas of clinical practice. The overall objective of this paper is to develop a validated and reliable self-assessment tool that can be used to quantitatively measure the core competencies of public health professionals in the state of Uttar Pradesh in India. The instrument can potentially be adapted for use in resource-poor settings globally.

3.3. Methods

Procedures for this study were broadly informed by the phases and steps outlined by Boateng and colleagues for developing and validating scales in health research (Boateng et al., 2018). Each phase and associated steps in this study are described below and in Figure 6. We conducted the study in three phases—item development, scale development, and scale evaluation. The item development phase entailed a formative process in developing a list of potential survey items based on the framework, Core Competencies for Public Health Professionals in Uttar Pradesh, India (Paper #1). This framework had 48 competency statements, and we reduced (combined and refined where appropriate) them to 37 items to create an initial tool. In the second phase—scale development—a quantitative assessment was

conducted among 166 professionals. The study utilized the pen-and-paper (PAP) survey methodology, in which data collectors handed out a hard copy of the questionnaire to each respondent. Exploratory Factor Analysis (EFA) was used for the extraction of factors. In the third phase—scale evaluation—we tested for reliability and construct validity of the scale. Specifically, we created index scores using the weighted sum approach, assessed the internal consistency of the index, and examined the strength of loading of items onto the factor extracted from EFA.

Figure 6. Three-phase COPHEC tool development process



3.3.1. Phase 1: Item development

Step 1: Item generation

In this step, we first specified the purpose of the construct we were seeking to develop, which was to create a composite measure of cumulative public health knowledge, skill, ability, and attitude of health professionals with public health responsibilities. Second, through the

review of relevant literature, we confirmed that there are no existing instruments that measure public health competencies in the UP setting or India at large.

Third, we utilized the framework of Core Competencies for Public Health Professionals in Uttar Pradesh for item generation. This framework identifies 48 competency statements organized across eight public health domains—public health sciences, analysis and assessment, policy and program management, financial management and budgeting, partnerships and collaboration, social and cultural determinants, communication, and leadership. We consolidated these forty-eight statements based on their similarities to create an initial tool of 37 items (Appendix 12). We merged items that were seemed homogenous (similar) and preserved those items that seemed heterogeneous (unique). We performed this consolidation at this point, rather than seeing if there was a high correlation between them during the analysis, for a practical reason. We wanted to reduce the cognitive burden to the participants, by shortening the length of the survey to the extent possible. Answering a survey requires respondents to invest a lot of cognitive effort. Previous research shows that lengthy surveys—surveys that require longer response time—can contribute to the cognitive burden, which can prompt a higher drop-out rate and diminished data quality (Lenzner et al., 2010). We wanted to ensure that respondents would be willing to invest the cognitive effort, and not refuse to take our survey because of its length.

Step 2: Content validity and face validity

Content validity refers to the "adequacy with which a measure assesses the domain of interest" (Hinkin, 1995). Establishing content validity for this tool meant evaluating the degree

to which the initial set of 37 items represented the "universe" of the construct of core public health competency.

Face validity is the "degree that respondents or users judge that the items of an assessment instrument are appropriate to the targeted construct and assessment objectives" (Haynes et al., 1995). Maintaining face validity in this study meant evaluating the acceptability of the core competency assessment instrument to the users and respondents in the UP context.

To a great extent, the content validity and face validity of the initial assessment tool of 37 items were achieved because we adapted these items from an already validated Core Competency framework (Paper #1). The following steps, which were taken as a part of the multi-step Delphi process to develop the framework, ensured that the framework was valid in the UP setting.

A narrative review was used to define the conceptual boundaries of the construct of core public health competencies. It entailed an appraisal and synthesis of the available core competency frameworks from around the world. These country-specific frameworks had been developed in consultation with a wide range of stakeholders, including practitioners, government agencies, and professionals' regulatory bodies. There have also been formal validity and reliability checks on the tools that were derived from some of these frameworks (Bartee et al., 2003; Poulton & McCammon, 2007). The frameworks were then synthesized into a preliminary list of competencies that may be relevant in UP.

Rapid semi-structured qualitative interviews were then conducted to identify context-specific core competencies to consider in UP. We interviewed six Indian experts who were knowledgeable about human resource development in public health and had familiarity with

the UP context. Interviews with these subject matter experts helped in updating the list of preliminary competencies relevant to the state of UP and ensuring that it represented all facets of core competency for public health professionals in the state.

This preliminary list of competencies became the starting point for a day-long workshop, which eventually generated a competency framework based on consensus. This panel of Indian public health experts and government officials had the knowledge and expertise to develop a framework that was relevant to and representative of the targeted construct. The process of discussion, debate, amendment, and eventually finalization in this group was particularly relevant in ensuring the content and face validity of the eventual competency items. These experts and officials asserted that the identified competencies cover the necessary public health domains in the UP context (establishing content validity) and, on the face of it, to be appropriate for the mid-level health officials (establishing face validity).

These validation steps, in turn, ensured the content validity and face validity of the initial tool as well. These competency statements were consolidated and refined to create the initial items in the COPHEC tool. The details of these and other steps of the competency identification process, which form Phase 1 of this research, are not presented here as it is presented elsewhere (Paper #1).

Additionally, the refinement of the initial 37-item tool with the help of local experts through translation and back translation partly contributed to achieving the face validity of the instrument. A team from the Indian language services company conducted the initial translation of the tool items into Hindi. Then a back-translation of the instrument from Hindi to English was conducted through another Indian translator fluent in both English and Hindi. This

translator had not seen the questionnaire before and did not have access to the first English draft. Once the translation and back-translation processes were complete, the first author and the members of the research team reviewed these documents over the course of several meetings. In these meetings, the team discussed the intent of each item, the literal translation, commonly understood the meaning of the item, and appropriateness of the word choice and phrasing in Hindi as well as English. The team made amendments when appropriate and finalized the tool. The finalized tool was deemed suitable for the intended purposes by the translation team.

3.3.2. Phase 2: Scale development

Step 3: Survey administration, sample characteristics, and sample size

Survey administration

The 37-item tool was administered among health professionals in UP in two samples. The first sample was a census of senior health professionals who work in the directorate of medical and health and the directorate of health and family welfare in Lucknow, the capital district of UP (N=84). The survey for this sample was conducted from September to November 2019. The second sample was a convenience sample of mid-level health professionals who work mainly in the Primary Health Centers (PHCs) across the state (N=82). For this sample, we approached those who were present for pre-service training at the State Institute of Health and Family Welfare (SIHFW), GoUP's training institute located in Lucknow. The participants belonged to three consecutive training batches. The surveys for the first, second, and third batches were conducted in September 2019, November 2019, and February 2020, respectively.

Our selection of the samples was guided by our interests and the need to learn about competency gaps among public health professionals in the state, district, and block levels—the three administrative divisions in UP (and India). Our sample of senior professionals provides a comprehensive picture of public health competency among health professionals at the state level. Our sample of MOs provides a glimpse of the public health competency gaps at the block level. There are more cadres in such as Block Program Managers (BPMs) and Health Education Officers (HEOs)—who do public health work in the blocks and are in supervisory or management positions —that we were planning to sample. We were also planning to sample public health managers and supervisors such as District Program Managers (DPMs) and Chief Medical Officers (CMOs) in the districts. However, the COVID-19 pandemic halted our plans. We plan to pursue this research in the coming months. Details of these planned activities can be found in the appendix section. Notably, our current sample or the planned research does not include junior level (frontline healthcare delivery) staff such as ASHAs and Anganwadi workers. While these cadres are critical parts of the public health workforce in the state, they are usually not in management or supervisory level positions, hence they are out of the scope of this study.

We selected experienced enumerators to collect data from the senior health professionals. The field coordinator (SuB) and other facilitators—each with a graduate training in public health—collected the data from the mid-level health professionals. The principal investigator (DHP) guided the data collection, while the field coordinator supervised the process.

Sample size:

For the administration of the COPHEC tool, we attempted to follow the sampling recommendation, stated in terms of the ratio of the sample size (N) to the number of variables (p). Ideally, the proportion of subjects to one variable would be between five to ten (Everitt, 1975; Gorsuch, 1983; Worthington & Whittaker, 2006). In this study, the number of variables (p) was 37 items, and a total of 166 health professionals were surveyed, which resulted in over four subjects to one variable for each sample.

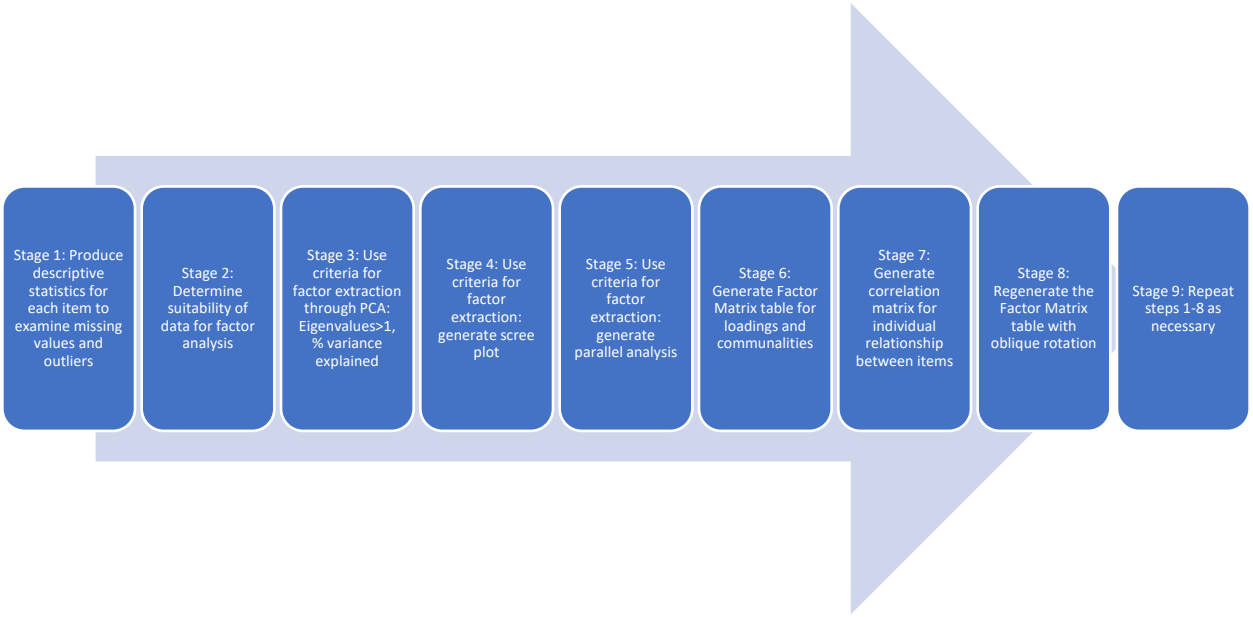
In the factor analysis literature, many researchers have discussed the issue of sample size (MacCallum et al., 1999; McNeish, 2017; Mundfrom et al., 2005). There is a general consensus that with larger sample size estimates tend to be more stable, sample factor loadings tend to be more precise estimates of the population loading, and estimates tend to be less variable across repeated sampling. However, there is a wide range of opinions about what "large sample size" actually means. For example, Gorsuch (1983) recommended sample size of at least 100, while Guilford (1954) argued for a minimum of 200. Comrey and Lee (1992) provided a rating scale for adequate sample size in factor analysis: 100 as poor, 200 as fair, 300 as good, 500 as very good, and 1000 or above as excellent. In terms of recommendations for the N:p ratio, Cattell (1978) suggested that the ratio should be in the range of 3 to 6, while Everitt (1975) recommended that this ratio should be at least 10. However, only a few of these recommendations have explicit evidence to support them. A common misconception is that the minimum sample is invariant across studies. However, several aspects of the individual study, such as level of communality and level of overdetermination (number of items per factor) of the factors contribute to the determination of sample size (MacCallum et al., 1999).

Step 4: Item reduction and extraction of factors

Data analysis was performed using STATA 14.0 statistical package. Data analysis followed steps for new scale construction identified by DeVellis (DeVellis, 2016).

Exploratory Factor Analysis (EFA) was utilized to identify a parsimonious list of factors that describe the core public health competencies (COPHEC) and generate factor scores that can then be used for subsequent analyses. EFA is a useful technique for studying competency, given the latent nature of the construct. Many competencies listed in the tool are not directly observed, and they can only be inferred through mathematical models. EFA allows us to explore the relationship between observed variables (the survey items) and the latent constructs (Goretzko et al., 2019). EFA also assists in "determining the number and the nature of unobserved latent variables that can be used to explain the shared variability in a set of observed indicators" (Preacher et al., 2013). The use of EFA on competency research is quite common in sectors ranging from management, education, and health. The method has been used for developing competency frameworks, determining indicators for competency assessment, and validating competency scales (Ghanbari et al., 2017; Liu et al., 2017; Spanierman et al., 2011; Weber et al., 2009). While EFA is used mostly in psychology research (Fabrigar et al., 1999), it is becoming increasingly common in public health sciences as well (Dale, 2014; Rodríguez et al., 2017; Borghi et al., 2018; Hasan et al., 2019).

Figure 7. Factor analysis steps used in the analysis



To conduct an EFA, we followed nine stages, also shown in Figure 7. First, we produced descriptive (univariate statistics) for each item to see if there are any issues with missing values or outliers. Second, we explored if the data is suitable for factor analysis by doing a test of "determinant" to examine that it is not equal to 0, and also conducted Kaiser-Meyer-Olkin (KMO) and Bartlett's tests. KMO value of 0.6 was used as the criterion for sampling adequacy, and Bartlett's test needed to be statistically significant (less than 0.05). Third, using Principal Component Analysis (PCA), we got a table of Total Variance Explained for each component. We considered the number of components that have Eigenvalues higher than 1. We then checked this cutoff with the percentage of variance and cumulative variance explained, choosing the total number of variables that cumulatively account for over 50% of the variance in the items.

Fourth, we developed scree plots to select the number of factors before the leveling off (the "elbow"). Fifth, we conducted a parallel analysis, which compares the eigenvalues generated from the data matrix to the eigenvalues generated from a Monte-Carlo simulated matrix created from a random set of equivalent size (Allen, 2017). We then compared the

results of these four methods—Eigenvalues greater than 1, variance explained, scree plot, and parallel analysis to decide on the number of factors to retain.

Sixth, we created a Factor Matrix table to show the loadings of each item on each factor and the communalities of the item. The value of 0.5 was used as the criterion for minimum factor loading and 0.3 as the minimum communality for that item to be retained (Costello & Osborne, 2005). Seventh, we created a correlation matrix to evaluate inter-item correlation and drop items with high correlations (greater than 0.8). Items with cross-loadings or that appear not to load uniquely on individual factors were deleted. Eighth, once we made the initial decision on the number of factors and items to retain based on the above steps, we regenerated the Factor Matrix table with oblique rotation to improve the interpretation of the factor. We chose oblique rotation—instead of orthogonal rotation—because we thought that the underlying latent variables might be somewhat be correlated with one another. Lastly, we repeated steps 6, 7, and 8 as necessary, considering different items and the number of factors. The factors were then used to generate factor scores, discussed further in Phase 3, Step 6.

3.3.3. Phase 3: Scale evaluation

Step 5: Test of reliability, construct validity, and criterion validity

Reliability

For reliability, Cronbach's alpha was used to assess the internal consistency of the final scale items belonging to the same factor. Cronbach's alpha measures how closely a set of items are related ranges from 0 to 1 and (Cronbach, 1951). A low Cronbach's alpha indicates that scale items are entirely independent of one another and are not correlated (or share no covariance). A higher coefficient indicates that items have shared covariance and probably

measure the same underlying construct. The alpha coefficient of 0.70 was used as the criterion for the acceptable threshold for this reliability.

Construct validity

Construct validity refers to how well the items on a questionnaire represent the underlying conceptual structure (Raykov & Marcoulides, 2010; Sheferaw et al., 2016). By examining the factor loadings in the rotated matrix generated from the Exploratory factor analysis (EFA), we assessed how different items align into conceptual constructs that describe core public health competencies.

Criterion validity

Criterion validity is the degree to which there is a relationship between a given test score and performance against a standard instrument, a gold standard (DeVellis, 2016; Raykov & Marcoulides, 2010). Given the absence of such a gold standard for measuring public health competencies in UP or India, we could not measure the criterion validity of the tool.

We did administer **a 12-item multiple-choice public health test** to our sample of 166 professionals to objectively measure their public health competencies. The objective test could perhaps be considered a form of criterion. More discussions on the relationship between self-assessed competencies of this study and the 12-item objective assessment are presented elsewhere (Paper #3).

Step 6: Scoring index items

Finalized items from the above steps were used to generate one factor and a set of factor scores, to be used in further analysis, including multiple regression analysis (Paper #3 of the dissertation). Factor scores were calculated using the post-estimation procedure. These are

composite variables that provide information about an individual's placement on the factor identified from the EFA (DiStefano et al., 2009). After the tool was developed, the results were analyzed separately for senior and mid-level health professionals.

Ethical consideration

Ethical approval for the project was provided by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB No: 00009035). The study was also approved locally by SIGMA-IRB, an independent ethical committee based in India. All respondents provided written informed consent before participating.

3.4. Results

3.4.1. Characteristics of the health professionals surveyed

Table 6 presents the demographic characteristics of the respondents disaggregated by the seniority level. In terms of public health training received, just over 80% of the senior professionals reported having received some in-service public health training. All mid-level professionals on the other hand reported receiving public health training, which is accurate given that all the respondents had recently attended the medical officer foundational training.

Table 6. Demographic characteristics of study participants disaggregated by seniority level

SN	Participants characteristics	Senior professionals (n=84)		Mid-level professionals (n=82)		Total (N=166)	
1	**Length of service in the UP's health system** (mean years, Std. Dev.)	27.59 (7.03)		2.48 (1.82)		15.19 (13.61)	
2	**Length of service in the current position** (mean years, Std. Dev.)	3.34 (2.62)		2.32 (1.77)		2.84 (2.29)	
		n	**%**	**n**	**%**	**n**	**%**
3	**Sex**						
	Male	66	79%	55	67%	121	73%
	Female	18	21%	27	33%	45	27%
4	**Current title (by seniority)**[7]					**All**	
4a.	*Senior professionals*[8]						
	Director	11	13%	0	0	11	7%
	Additional Director (AD)	13	15%	0	0	13	8%
	Joint Director (JD)	56	67%	0	0	56	34%
	Other	4	5%	0	0	4	2%
4b.	*Mid-level professionals*[9]						

[7] The titles of Director, AD, and JD are only applicable to senior health professionals, so these options were not provided to the sample of mid-level health professionals. Similarly, the titles of MO and MOIC are only applicable to mid-level health professionals, so these options were not provided to the sample of senior health professionals.

[8] In the directorate of medical and health and directorate of health and family welfare, directors are ranked higher than Additional Directors (ADs), who are ranked higher than Joint Directors (JDs). Each of the 12 departments (e.g., training, paramedical, nursing) in the directorate of medical and health, and the two departments (family welfare, and maternal and child welfare) in the directorate of health and family welfare typically have one sanctioned director, between one to four ADs, and between one to six JDs.

[9] A Medical Officer-In-Charge (MOIC) is usually the head of a Community Health Center (CHC) in a block, while an MO leads the Primary Health Center (PHC).

	Medical officer in charge (MOIC)	0	0	5	6%	5	3%
	Medical officer (MO)	0	0	77	94%	77	46%
5.	**Some public health training received**						
	Yes	68	81%	82	100%	150	90%
	No	16	19%	0	0	16	10%
6.	**Highest education level**						
	Bachelors	61	73%	78	95%	139	84%
	Master's	6	7%	2	2%	8	5%
	Doctorate	17	20%	2	2%	19	11%

3.4.2. Factor analysis

Missing data analysis showed that data were Missing Completely at Random (MCAR) (Appendix 13 and Appendix 14). We used Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity to confirm the suitability of data for factor analysis. The KMO value for the COPHEC index was 0.93, indicating that underlying factors might explain the proportion of variance in the variables. Bartlett's test of sphericity was $\chi 2\ (666) = 4303$, $p < 0.0001$, indicating that the correlation between items was sufficiently large to run a PCA. Both of these tests indicated that the use of factor analysis is appropriate. Correlation matrix showed there were no items with a correlation greater than 0.8, so no items were deleted based on this criterion (Appendix 15).

The PCA suggested one component explaining 53% of the variation in the initial 37-item scale solution for the sample (Appendix 16). The scree plot suggested the retention of one component (Appendix 17). The parallel analysis confirmed the retention of one component (Appendix 18 and Appendix 19). This one factor—which we named core public health competency—was used to generate the COPHEC index.

During the extraction process, all items met the minimum threshold of factor loadings and communalities, so no items were deleted (see Table 7). Table 7 includes the pattern matrix, showing the correlation between each of the final items and the component extracted after the iterative process.

We chose to pool our data from mid-level and senior professionals to run the factor analysis. Our reasonings for pooling fell under two major categories—conceptual and analytical. Conceptually, these two groups were found to be more similar in their backgrounds (education, experience, and topics they deal with in their work) than they are different. They differ in the

length of their service in the UP's health system—senior health professionals have served for a more extended period and may also have higher competencies in supervision and decision-making than the mid-level professionals. Also, the levels of responsibilities between the two groups are different. Senior-level professionals may spend more time in developing organizational policies, but they may have less programmatic responsibilities than mid-level professionals. Lastly, senior professionals are several steps removed from the frontline staff, while the mid-level officers are more proximal.

In terms of similarities, the educational backgrounds of both groups are alike. Almost all are clinical doctors with an MBBS degree[10]. There are also similarities in their experiences. Senior-level health professionals usually get promoted to their positions after serving as mid-level health providers for a certain number of years. Also, while both groups hold different roles, they often deal with similar topics. These topics broadly include developing and implementing public health programs, supervising staff, providing technical expertise, setting vision and strategy for their health units, and creating a culture of quality within the organization. The same survey was administered to both of these groups because the target population for this study was health professionals with program management or supervisory roles in public or population health, and those who are senior to the frontline staff (i.e., ASHAs, Anganwadi workers). Both the senior and mid-level health professionals fit this criterion.

[10] MBBS (Bachelor of Medicine, Bachelor of Surgery) is an undergraduate medical degree that trains high school graduates in the field of general medicine and general surgery. Countries like India, which follow the United Kingdom medical education system, confer the MBBS degree. In contrast, countries that follow the United States medical education model confer a Doctor of Medicine (MD) to medical graduates. Some MBBS degree holders pursue additional training through three to four-year of residency and they receive an MD in specialties like pulmonology, cardiology, and dermatology.

Analytically, we found the results from PCA, scree plots, and parallel analyses to be similar when these analyses when conducted separately for mid-level and senior professionals. The PCA results showed that almost 50% of the variance in both groups was explained by a single factor. Also, the results from scree plots and parallel analysis suggested retention of one factor in the factor analysis for both of these groups.

Factor scores

The factor score coefficients of the individual items in the final 37-item COPHEC index are included in Table 7. The scores were generated after rescaling the standardized factor score, ranging from 0 to 100. The mean competency score overall was 58.61, while the standard deviation was 19.36. Disaggregating by the seniority level, the mean competency score for mid-level health professionals was 63.4, with a standard deviation of 15.74. For senior-level health professionals, the mean competency score was 54.8, with a standard deviation of 21.7.

3.4.3. Reliability and validity assessments

Reliability

Analysis of inter-item correlation showed good internal consistency with Cronbach's alpha of 0.97 for the full 37-item index.

As described in the methods section, we did not measure test-retest reliability and interrater reliability because of the design of the study. The study design for senior health professionals enabled a single measurement from each respondent. The survey for mid-level health professionals was administered twice—before the start of the pre-service training program and its end. However, this also meant we could not appropriately measure the test-

retest reliability as the training was intended to improve competencies and would introduce bias. So, only the post-training test scores were used for this study.

We were unable to measure interrater reliability either because the survey was conducted by handing out the paper survey to respondents who filled it out on their own. While the interviewers answered any clarifying questions, they did not conduct verbal interviews to elicit responses from the research participants.

Content validity and face validity

Content validity and face validity of the COPHEC index were assured primarily through the methodological rigor of the process to come up with the Core Competencies framework.

Even though the framework was developed specifically for mid-level health professionals, we think the competencies generated are comprehensive enough to apply to senior professionals as well. These competencies may be required at different proficiency levels for different cadres depending on the nature of their job responsibilities. However, it is common to have a similar set of competencies for mid-level and senior officials, as evident by competency frameworks in the US and Canada.

Additionally, the face validity of the instrument was strengthened through the refinement of the tool through the translation and back-translation process.

Construct validity

Construct validity of the COPHEC index was confirmed by high average factor loading of components ranging from 0.62 to 0.80. Ideally, we would examine the components correlation matrix for the rotated final components as another measure of construct validity. However, we were unable to do so because we were left with only one component in the final tool.

3.5. Discussion

This study presents a novel tool to assess self-reported core public health competencies in UP and broadly in India. We envision the COPHEC index to apply and be relevant to both mid-level and senior officials, but we are not expecting the competency scores would be identical between the two groups. While the base competencies might be similar between the two groups, competencies may be required at different proficiency levels depending on the nature of their job responsibilities.

For factor analysis, we pooled our data between the two samples of mid-level and senior professionals. Our choice to pool could be questioned on the basis that there were some conceptual differences between these two groups, as described earlier. We could have employed a different approach, for example, developing the framework with one sample (using EFA) and confirming it with the other set (using CFA). However, upon consideration of various approaches, we decided to pool anyways because we wanted to identify factors for these public health professionals across seniority, experience, work activities, and location of services—the characteristics that make these samples different.

The majority of competency assessment tools available in the literature are for clinical health professionals like doctors and nurses. Their competencies are usually measured through a set of distinct maneuvers, clinical vignettes, cognitive tests, and other techniques (Miller, 1990). While public health measurement researchers can learn from those techniques, assessment methods other than self-reports can be highly time-intensive, requiring observations and performance of skill tests (Epstein & Hundert, 2002). Also, public health competency assessments may not allow for distinct physical maneuvers or manipulations

performed in a short timeframe. Physical maneuvers can include the use of patient simulators (a manikin) to mimic clinically realistic scenarios such as a cardiac arrest that require the examinee to respond appropriately (e.g., provide chest compressions) (Good, 2003). In addition, unlike clinical competency assessments that may entail standardized patients or audit of clinical practice, there may be no objectively verifiable standards for measuring public health competencies like leadership and communication in many settings. These and other measurement challenges have contributed to the lack of research in this area (Issel et al., 2006b). The majority of public health competency assessments that have been conducted include self-assessments, and they come from High-Income Countries (HICs) (Issel et al., 2006a; Lin et al., 2010; Poulton & McCammon, 2007; Public Health Foundation, 2014).

Despite the limitations of the self-assessment technique, it can provide valuable and accurate data if the survey is constructed well. Apart from being one of the cheapest and quickest ways to receive information on competency, self-assessments have many benefits. It can influence health worker's behavior to increase compliance with quality standards (Adamow, 1982; Love & Hughes, 1994); allow health workers to reflect on their own strengths and weaknesses for improvement; enhance self-esteem and awareness (Best et al., 1990); provide health workers ownership of the evaluation process; improve communication between supervisors and subordinates (Harris & Schaubroeck, 1988); help identify the transferable skills of workers (Mayall & Maze, 1985); and reinforce new skills or behaviors among health workers to improve performance (Bose et al., 2001).

In the UP setting, self-assessments are particularly suitable for a few reasons. First, many public health professionals in the community may be working unaccompanied by peers or

supervisors. So, competency assessment through techniques like 360-degree assessments may not be possible. Second, Indian bureaucracy is marked with strict hierarchy and deference, with limited space for subordinates to voice their opinions (M. R. Kumar, 2007). So, even in situations where it is possible to receive supervisors' assessments, it might be ideal for employees to participate in their own assessment. This is more likely to empower them by providing a sense of ownership of the evaluation process. Third, given that UP is a resource-constrained environment (V. Kumar & Mishra, 2015), the low cost associated with self-assessments makes the technique particularly appealing.

Our reasoning for conducting EFA requires further explanation. We chose to conduct EFA, even though there were domains already identified in the Core Competency framework (Paper #1), but these were theoretically determined, and no psychometric assessments have been done to suggest the factorability of these domains and any related items. When domains are defined *a priori,* Confirmatory Factor Analysis is usually performed to confirm the factor structure already outlined in an established theory (Gallagher & Brown, 2013). However, for this study, we let the factor structure be determined through statistical computation rather than assign them *a priori*. We chose the EFA route, instead of the CFA route, for a couple of reasons. First, the domains identified in the Core Competency framework were determined heuristically during the Delphi process to organize the competencies. So, there was a need to explore the factor structure of the public health competency construct using empirical data, as it had not been done previously in the UP context. While we had expectations about the nature of underlying constructs of factors—that public health competency might be multidimensional—EFA did not require us to declare these expectations, and the analysis was

not influenced by these expectations (Thompson, 2004). CFA, on the other hand, required us to have specific expectations regarding the number of factors, the variables that reflect the given factor, and whether the factors are correlated (Gallagher & Brown, 2013). Since we did not have such firm expectations, we took the EFA approach. Such use of EFA—to identify the underlying dimensions or constructs for competency—have been conducted by researchers, although these studies are intended for the clinical workforce, mostly in high-income countries (Ghanbari et al., 2017; Hsu & Hsieh, 2013). Second, we wanted to understand whether the observed data reveal a different underlying factor structure than the one proposed in the Core Competencies framework. If we did find differences, then ideally, we would follow up with another study with a larger dataset to confirm the factor structure.

The EFA in this study identified one factor that explained the majority of the variance in our data. This finding is different than what we saw in the scientific literature from high-income countries, where EFA analysis of public health competencies has yielded up to ten domains (Brocklehurst & Rowe, 2003; Mumford et al., 2016). Our finding in this study is also different than our previous study that had eight domains. This suggests that further research in UP may be necessary to confirm our factor structure.

The results of this study suggest that three competencies—items CA.01, CA.17, and CA.20 (see Table 7)—appeared to have less prominence as indicated by their low factor loadings. There might be various reasons for this. Compared to other competencies, item CA.01 (describing key concepts in public health) might not be as applicable to public health managers and supervisors, specifically to mid-level health professionals. This is because this competency relates to the ability to describe concepts like the relationship between health and poverty.

Even though health practitioners might find it beneficial to know these concepts, the focus in their jobs might be on the application of competencies rather than describing a concept alone.

Item CA.17— managing time appropriately—also had a low factor loading in the final tool. UP, faces numerous resource constraints, and there are persistent health systems challenges like lack of access to essential services, overcrowding of clinics, and medicine shortages. So, time management may be considered an obvious necessity for public health professionals, something that is a given, and not as necessary to be pointed out as a competency to be possessed (and measured).

Lastly, item CA.20—making use of financial analysis and accounting techniques in decision making—might also have had lower loading as the final survey item because of its relevance to only some health workers. This competency calls for a particular type of skillset. Moreover, some, not all, health professionals might be expected to possess this competency for their jobs. Future research can include the development of a tool to assesses functional competencies like this, which are job-specific and technical or operational.

Apart from the reasons listed above, these three items may have had lower loading because the health professionals are neither trained nor explicitly asked to address these issues. This brings us to the discussion about the nature of the survey itself. The survey asks respondents about their level of proficiency in a particular competency, not about the importance of that competency in their jobs.[11] This is a subtle but important distinction as it has an implication in the interpretation of the results. The results should be interpreted to be the

[11] Note that in the Delphi exercise discussed in Paper #1, participants identified what competencies are essential for mid-level managers, and not how proficient they are in these competencies.

level of competence of health workers and not the importance of competencies for these workers. In other words, the higher the score, the more competent they are (not how vital the competencies are). So, while the three aforementioned competencies have lower factor loadings, they might still be applicable, but the respondents did not find themselves to be as proficient in these competencies.

A strength of this study is that it utilized many psychometric recommendations, which helped in producing a tool with good validity and reliability. However, several limitations should be noted. The first relates to sampling. The study included a convenience sample of mid-level health professionals present in the training program offered by SIHFW. SIHFW independently handles the selection process of these MOs for the training programs. Usually, the process involves SIHFW identifying a few districts that were not represented in previous training batches. They then send a letter to the Chief Medical Officers (CMOs) of these identified districts, asking them to pick MOs to attend the training. CMOs are supposed to make their selection based on two criteria—MOs should in their jobs for less than two years, and they should not have attended this training previously. We are unable to determine the extent of bias in our sample because we do not know how these trainees were selected at an individual level by the CMOs. However, we can assume it may be somewhat representative of the population of MOs in their cohort. This is because there is some systematic sampling happening at the district level, as SIHFW cycles through the districts represented in the training program. Regardless, the results from this study should be interpreted cautiously, as findings may not be generalizable to the target population. To address this limitation, a more extensive study is being planned across the state that relies on probability sampling.

The second limitation relates to self-assessment. Previous research shows that data collected using self-reports tend to suffer from the Dunning-Kruger effect, a cognitive bias in which respondents assess their abilities as higher than it is (Kruger & Dunning, 1999). While the self-assessment tool helps in providing us some information about competencies, adding a knowledge assessment module to supplement it would be helpful to evaluate the extent of the bias. Future research should discuss in detail the Dunning-Kruger effect as it relates to this study. The rescaled score generated from this study can be used for regression analysis in such research. Researchers can also explore in detail the differences in the competency scores between senior and mid-level health professionals and the relationship of self-assessed competencies with objective questionnaires (these analyses are part of Paper #3 of the dissertation).

The third limitation is about the subject to item ratio related to the sample size for EFA. The ratio for this study was just over four, lower than the suggested ratio of five to ten. These suggestions are provided by many researchers (Cattell, 1978; Everitt, 1975; Hair et al., 1995; Paul Kline, 1994). However, studies show that these recommendations are inconsistent, and there is little empirical evidence to support them, so they are gradually being abandoned (Arrindell & van der Ende, 1985; Jackson, 2001; MacCallum et al., 1999; Mundfrom et al., 2005). There is also research that shows that even with a smaller sample size, the findings of an EFA can be valid under certain conditions including high factor loadings, few factors, and high communalities as seen in this study (de Winter et al., 2009; Gagne & Hancock, 2006; MacCallum et al., 1999; Mundfrom et al., 2005; Velicer & Fava, 1998).

Future research on this topic can be conducted in the following three sets of areas. The first area is about understanding the phenomenon of competency. Researchers should examine how health worker competencies translate into their performance. In a way, performance could act as a criterion for competency, i.e, higher competency could lead to better performance. However, we know that this relationship may be confounded by variables such as workplace culture and individual motivation. So, more research is necessary to untangle this relationship. Additional research is also necessary to understand how individual competencies contribute to not just individual health worker performance but the team as well as organizational performance in low- and middle- income settings. Statistical models that explore competency's determinants like the length of service and gender should also be investigated. Lastly, more research is necessary to explore how self-assessment of competency fares with other forms of assessment methods like objective evaluation using standardized exam questions or vignette tests. Findings from these studies can inform the validity of the COPHEC index.

The second area of future research includes exploration of the practical applications of competency measurement. Researchers can conduct studies to analyze the feasibility of incorporating competency assessments as a part of licensure and accreditation requirements for public health professionals. Continued accreditation and licensure are routine practice in many fields like aviation and clinical medicine. They can help standardize the profession and require professionals to continuously improve and remain up to date with the latest scientific and technological changes. It would be important to explore the capacity, authority, and accountability of different government agencies in UP and other low-resource settings to undertake the licensure and accreditation efforts. Researchers could explore the feasibility of

incorporating technology, including digital badges, to streamline the licensure process. Future research should also incorporate longitudinal and repeated cross-sectional designs to monitor how competencies change over time. Conducting periodic assessments has many programmatic advantages. For example, it can help gauge how long the improvements in competencies achieved through interventions like training can be sustained and what factors contribute to such sustenance. Results from such research can inform the nature of programmatic interventions, including the frequency of in-service training programs.

The third area of future research includes further calibration of the COPHEC tool. Confirmatory factor analysis in other samples in UP or similar resource-poor settings can be conducted to confirm the factor structure of the COPHEC index. Also, exploratory factor analyses can be used to revise the instrument in other resource-poor settings similar to UP within India, and other LMICs. These studies should rely on probability sampling to ensure that the results are generalizable to the target population. While extending the generalizability of our tool to the target population in other settings, researchers should carefully compare the medical/public health education and health systems in those settings. Such comparison would be important to characterize the background of professionals who enter the public health workforce and the values as well as priorities of the health system. All of these are important variables to consider as they might impact the type of public health services the system is expected to provide, the types of jobs that public health professionals are expected to fulfill, and the competencies necessary to fulfill those jobs effectively.

3.6. Conclusion

Despite the recognition that improving health workers' competencies are important to achieve UHC, most HRH indicators only measure the availability and distribution of health workers. Indicators that do focus on competencies relate mostly to the clinical workforce. While there are very few studies that have measured public health competencies, they come from HICs and there are no reliable and validated tools for such measurement in low-resource settings like UP. The 37-item COPHEC index helps to fill that gap–it was found to be a valid and reliable measure of core public health competency among health professionals with management and supervision roles in UP.

The tool presented here would be most useful if ministries of health self-initiate the assessment as a way to generate productive discussions around current capacities to meet public health needs, including response to public health emergencies. Specifically, they can use this instrument to inform training programs based on competency assessment gaps; evaluate training effectiveness by measuring competency acquisition before and after training; assess the level of competencies among potential recruits to make hiring decisions; improve performance management including the promotion of adequately competent professionals; and incentivize in-service training programs to improve certain competencies among health workers.

Table 7. Pattern matrix and factor scoring coefficients of the final COPHEC index

Item #	Item	Factor loading	Uniqueness	Factor scoring coefficients
CA.01	Describe key concepts in public health (e.g., the health status of populations, the determinants of health and illness, strategies for health promotion, relationship between health and poverty, inequities in health and various forms of disadvantages, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.)	0.604	0.635	0.022
CA.02	Apply the public health tools, techniques, and sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice (e.g., community needs assessment).	0.652	0.575	0.027
CA.03	Use data, evidence, and research to inform health policies, programs, and organizational performance.	0.674	0.546	0.029
CA.04	Identify relevant and appropriate sources of information, including community resources.	0.692	0.521	0.031
CA.05	Collect, store, retrieve and use accurate and appropriate data on public health issues.	0.699	0.512	0.032
CA.06	Analyze information to determine appropriate implications, uses, gaps, and limitations.	0.687	0.529	0.031
CA.07	Assess the accuracy and importance of data for public health decision making.	0.680	0.537	0.030
CA.08	Describe selected policy and program options to address a specific public health issue.	0.716	0.488	0.035
CA.09	Describe the implications of each policy and program option, especially as they apply to the determinants of health and recommend or decide on a course of action.	0.677	0.542	0.030

Item #	Item	Factor loading	Uniqueness	Factor scoring coefficients
CA.10	Develop a plan to implement a course of action taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).	0.754	0.431	0.041
CA.11	Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses) to address a specific public health issue.	0.756	0.428	0.042
CA.12	Monitor and evaluate an action, policy, or program.	0.710	0.497	0.034
CA.13	Demonstrate the ability to fulfill functional roles in response to a public health emergency.	0.766	0.414	0.044
CA.14	Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining scope of work and timeline).	0.805	0.352	0.054
CA.15	Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).	0.702	0.508	0.033
CA.16	Support learning within an organization including on the job training to advance public health goals.	0.690	0.525	0.031
CA.17	Manage time appropriately.	0.600	0.640	0.022
CA.18	Justify programs for inclusion in budgets, develop and defend budgets.	0.630	0.603	0.025
CA.19	Prepare proposals for funding (e.g., foundations, government agencies, corporations).	0.648	0.580	0.026
CA.20	Make use of financial analysis and accounting techniques in making decisions about policies, programs, and services.	0.578	0.666	0.021

Item #	Item	Factor loading	Uniqueness	Factor scoring coefficients
CA.21	Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).	0.636	0.596	0.025
CA.22	Identify and collaborate with partners in addressing public health issues.	0.773	0.403	0.045
CA.23	Use skills such as team building, negotiation, conflict management, group facilitation, and mediation between differing interests to build partnerships.	0.809	0.345	0.055
CA.24	Mobilize communities by using appropriate media, community resources, and social marketing techniques.	0.737	0.456	0.038
CA.25	Recognize how the determinants of health (biological, social, cultural, economic and physical) influence the health and well-being of specific population groups.	0.729	0.469	0.037
CA.26	Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.	0.756	0.429	0.042
CA.27	Apply culturally-relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status, sexual orientations and abilities.	0.735	0.459	0.038
CA.28	Listen, engage, and communicate effectively (e.g., by leveraging technology) with individuals, families, groups, communities, and colleagues including supervisors and team members.	0.759	0.425	0.042
CA.29	Interpret information for professional, nonprofessional and community audiences.	0.801	0.359	0.053
CA.30	Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.	0.726	0.474	0.036

Item #	Item	Factor loading	Uniqueness	Factor scoring coefficients
CA.31	Describe the mission and priorities of the public health organization where one works, and apply them in practice.	0.757	0.426	0.042
CA.32	Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.	0.776	0.397	0.046
CA.33	Utilize public health ethics to manage self, others, information, and resources.	0.796	0.366	0.051
CA.34	Contribute to maintaining organizational performance standards.	0.749	0.440	0.040
CA.35	Build community capacity by sharing knowledge, tools, expertise, and experience.	0.753	0.433	0.041
CA.36	Identify a need for change, manage change and processes.	0.734	0.462	0.038
CA.37	Maintain organizational justice, equality, and fairness in dealing with subordinates.	0.682	0.535	0.030

4. Individual-level factors associated with performance on an objective core competency test: findings among public health professionals in Uttar Pradesh, India (Paper 3)

4.1. Abstract

Measurement of core competencies of public health professionals helps to identify training needs, evaluate the effectiveness of training programs, and improve performance management. However, the competencies of public health professionals are rarely measured in Low- and Middle-Income Countries (LMICs). It is rarer for these studies to utilize objective measurement techniques like standardized tests to assess public health competencies and to explore the factors that predict the level of performance on these tests. The objective of this study is to examine whether individual-level factors such as sex and education are associated with performance on an objective test measuring core competencies of public health professionals in Uttar Pradesh (UP), India.

To objectively measure competencies, we administered a 12-item multiple-choice public health test to 166 mid-level and senior public health professionals in management or supervisory roles in UP. We also administered a 37-item Core Public Health Competency (COPHEC) tool to measure the level of self-assessed competencies. Demographic variables such as sex, duration of service in their post, and education level were also assessed. Analyses included bivariate analyses, such as two-sample t-tests to assess the equality of means between senior and mid-level professionals on objectively measured as well as self-assessed competency scores. We also performed a multiple linear regression with objectively measured competencies as the dependent variable and self-assessed competencies as well as demographic variables as independent variables.

Out of 12 objective measures, only four questions were answered correctly by more than 50% of all respondents. The findings of the two-sample t-test showed the difference

between senior and mid-level professionals in self-assessment as well as objective measurement to be statistically significant. On average, mid-level professionals had lower objective measurement scores compared to senior health professionals, but higher self-assessment scores. Findings from the multiple linear regression showed that seniority is a statistically significant predictor of objectively measured competencies. On average, senior health professionals scored 13 points higher (on a 100-point scale) than the mid-level health professionals on the objective measurement. Other variables including self-assessed competencies were not found to be statistically significantly associated with performance on the objective test.

Low objective measurement scores in our test indicate significant gaps in competencies to perform public health functions, and opportunities to deploy measures like competency-based training to address these gaps. Mid-level professionals had lower objective measurement scores but higher self-assessment scores than senior professionals. Their overestimation of their competencies perhaps indicates a cognitive bias in which poor performers in the objective test are not only deficient in their competencies but also unaware of their deficiency. This phenomenon is called the Dunning-Kruger effect. Seniority in rank was found to be significantly associated with performance on the objectively measured competency test and not variables such as the duration on a job. This indicates that responsibilities may matter more in ensuring higher competency than time on the seat. Alternatively, it could mean that the health system is good at identifying people who are more competent and promoting them. Self-assessment of public health competency correlated poorly with competencies measured objectively, indicating that public health professionals in the study could not accurately self-assess their

competencies. Their ability to correctly self-assess may improve by removing their cognitive bias through additional training, demonstration of variation in performance, and feedback to strengthen their competencies.

Keywords: public health, competency measurement, human resources for health, India

4.2. Background

Identifying, measuring, and improving competencies of public health professionals are essential steps to achieve Universal Health Coverage (UHC) (World Health Organization, 2000, 2006; Willis-Shattuck et al., 2008; Peters et al., 2010). However, in many low resource settings, including Uttar Pradesh (UP) of India, there are no agreed set of core public health competencies. Core competencies are the key knowledge, skills, abilities, and attitudes that the health workforce should possess to effectively deliver essential public health services (Public Health Foundation, 2014; World Health Organization, 2018). This absence contributes to the challenge of ensuring that public health professionals are capable of fulfilling essential public health functions like conducting disease surveillance, responding to public health disasters, managing health programs, and implementing plans to address public health problems in the community.

Beyond the identification of competencies for health professionals, there is a need to measure those competencies to identify training needs, evaluate the effectiveness of training programs through participants' competency acquisition pre- and post-training, and inform workforce development efforts in recruitment and performance management (Kak et al., 2001). Furthermore, as evident in clinical medicine, different levels of competencies may help predict health worker performance and patients' health outcomes (Epstein & Hundert, 2002; Norman, 1985). Other disciplines such as management, aviation, and education have documented that a higher competency of workers could contribute to higher quality outcomes, performance, and safety (Dreyfus, 2008; Skorupski & Wiktorowski, 2014). For example, greater professional competencies of teachers are considered to play a determinant role in enhancing the quality of

education, including student's test score achievement (Darling-Hammond & Bransford, 2007). Patients' perceptions of the level of provider competencies also impact their care-seeking behavior. In a study of competence and bypassing of primary health centers in India, Rao and Sheffel (2018) found that a higher level of provider competency can substantially reduce patients bypassing the nearest government health center offering free or subsidized services for more expensive care elsewhere (K. D. Rao & Sheffel, 2018). While there is a need to conduct similar studies in public health—to understand the impact of competency in the performance of public health workers and the health system—the aforementioned findings from other disciplines can aid in generating research hypotheses.

Despite the importance, studies that measure the competencies of public health professionals in Low- and Middle-Income Countries (LMICs) are rare. The lack of validated competency frameworks in many LMICs limits the ability of researchers to develop tools that are applicable in these settings.

Even rarer are studies that utilize objective methods such as a standardized test to measure public health competencies. There may be various reasons for this research gap. For example, it may be challenging to objectively measure competencies in areas like management and leadership, domains that are usually explored in public health competency studies (Fetene et al., 2019; Heerdegen et al., 2020; Martineau et al., 2018). Also, a lack of reliable and valid tools to objectively measure competencies in many LMICs could contribute to this gap. These research gaps have also led to a dearth in studies that explore the variables that are associated with performance levels on objective measurement of public health competencies.

UP is home to almost 230 million people (Ministry of Home Affairs, Government of India, 2011), and as with many states in the country, it continues to face several health workforce challenges. There are currently an estimated 9.1 health workers per 10,000 population compared to the WHO proposed Sustainable Development Goal index threshold of 44.5 health workers per 10,000 (World Health Organization, 2016c). There are no requirements and few opportunities for health workers to receive public health training, making it challenging to deliver essential public health functions (EPHFs) for population health or professionally manage health services. Also, there may be discrepancies between professional competencies and population health priorities, an unsuitable mix of competencies among the health workforce, the maldistribution of professionals across geographical areas—specifically rural and urban regions (Global Health Workforce Alliance and WHO, 2008; M. Rao et al., 2011). In UP, public health professionals have a wide range of responsibilities—conducting disease surveillance, responding to public health disasters, managing health programs, and developing plans and programs to address public health problems (National Health Mission, 2012). However, most often, they only possess formal clinical training. Quantitatively identifying gaps in core competencies for public health professionals in UP provides a basis to address some of these challenges. Also, understanding the individual-level factors associated with public health competencies can help identify optimal approaches and interventions for improving those competencies among public health professionals.

The purpose of this study is to examine the relationship between objectively measured competencies with self-assessed competencies and demographic variables. It builds on the findings of our previous studies. We recently developed a framework that entailed a consensus

set of core competencies for public health professionals in UP (Paper #1). Building on this framework, we developed the Core Public Health Competency (COHEC) tool using the self-assessment technique to measure competencies (Paper #2). It found the tool to be valid and reliable.

We measure objective public health competencies in this study using test questions on core areas of public health practice such as management, analysis and assessment, and public health sciences. The competencies listed in the measurement tool draw on multiple public health disciplines and are not specific to a single program or topic.

We examine self-assessment as an independent variable to evaluate if public health professionals in the sample were able to accurately assess their competencies. Previous research from other disciplines ranging from law to psychology shows that self-assessments are poor predictors of objectively measured competencies (Ward et al., 2002). However, this relationship is understudied in public health. Our null hypothesis was that there is no statistically significant association between self-assessed competencies and objectively measured competencies. Our alternative hypothesis was that these two variables are positively correlated—the higher the self-assessed competencies, the higher the objectively measured competencies.

Other independent variables considered for the analysis were six demographic characteristics of the public health professionals—sex, duration on the job, duration in the UP's health system, education level, public health training, and seniority. Previous research shows that there are sex differences in self-perception of competency, with variance evident as early as in elementary school (Bouffard et al., 2003). Also, it is well documented that a person's

perceptions of competence about another individual are influenced by that other individual's sex (Fiske et al., 2002). Similarly, previous research shows that more experience can contribute to higher levels of competency (Spencer & Spencer, 1993). Positive associations are also documented in the literature between competency and variables such as education level and prior training (Chang & Huang, 2005). These research findings are from disciplines other than public health. The influence of these demographic variables on competency is unexplored among public health professionals in low resource settings like UP, with objectively measured competencies as the outcome variable.

With these research gaps in mind, our study tried to answer the following research question: are self-assessed competencies (measured using the COPHEC index) and demographic characteristics of public health professionals in UP associated with their performance on an objective core competency test? We started with univariate analyses—by determining the levels of objective competency scores among all public health professionals, and also separately for mid-level and senior professionals. We then conducted bivariate analyses—assessing differences between mid-level and senior professionals on the objectively measured competencies and self-assessed competencies. Lastly, we ran multivariable analyses—identifying whether self-assessed competencies and demographic variables of public health professionals are associated with higher objectively measured competency scores.

4.3. Methods

4.3.1. Data source

The objective measurement tool was self-administered among health professionals in UP in two samples. The first sample of 84 respondents was based on a census of senior health professionals who work in the Directorate of Medical and Health and the Directorate of Health and Family Welfare in Lucknow, the capital district of UP. The survey for this sample was conducted from September to November 2019. The second sample of 82 respondents was a convenience sample of mid-level health professionals who work mainly in the Primary Health Centers (PHCs) across the state as Medical Officers (MOs). For this sample, we approached all those who were present for pre-service training at the State Institute of Health and Family Welfare (SIHFW), GoUP's training institute located in Lucknow. The participants belonged to three consecutive training batches. The surveys for the first, second, and third batches were conducted in September 2019, November 2019, and February 2020, respectively. The self-assessment tool (COPHEC) was also administered to the same groups, and questions about demographic characteristics were also asked.

More details on how these MOs are selected for the training are provided elsewhere (Paper #2), but briefly, SIHFW independently handles the selection process. Usually, they cycle through 75 districts in UP—they attempt to bring MOs working in districts that were not represented in previous training batches. They then send a letter to the Chief Medical Officers (CMOs) of these identified districts, asking them to pick the MOs to attend the training program. CMOs are supposed to choose MOs who have been in their jobs for less than two

years and who have not attended this training previously. However, we are unable to verify the extent to which CMOs follow these guidelines.

4.3.2. Tools and measures

Objective tool:

The objective measurement tool included 12 questions that broadly assessed public health competency ranging from calculation of infant mortality rate to selection of the correct definition of public health surveillance using the multiple-choice format (see Appendix 20 for the objective tool). These items were adapted from the following sources: practice exams for the National Board of Public Health Examiners, Centers for Disease Control and Prevention's post-lesson quizzes, online public health training assessment from the University of Albany Center for Public Health Continuing Education, and training course overview of *isee systems*—a systems thinking software company that has developed dynamic models for public health and public policy (Centers for Disease Control and Prevention, 2018; isee systems, 2018; National Board of Public Health Examiners, 2018; University at Albany Center for Public Health Continuing Education, 2018).

Our selection of questions from these sources was guided by two major considerations. First, we chose questions that aligned with the eight public health domains—public health sciences, assessment and analysis, policy and program management, financial management and budgeting, partnerships and collaboration, social and cultural determinants, communication, and leadership—from the core competency framework we developed in UP (Paper #1). We ensured that there was at least one objective question that aligned with each domain. Second, we utilized two established frameworks—Bloom's taxonomy and Miller's pyramid—to pick

items that demanded higher-level reasoning from the respondents (Bloom, 1965; Miller, 1990). See Appendix 21 for a figure of Bloom's taxonomy and Appendix 22 for a figure of Miller's pyramid. These selected questions encouraged respondents to apply, analyze, synthesize, and evaluate information rather than just recall terms, facts, and details. These questions also focused on assessing the skills with which knowledge can be applied rather than assessing just the knowledge of the health worker—the facts and information that the health worker possesses. During the process of developing the tool, we also considered exam questions administered in UP to hire Monitoring and Evaluation (M&E) officers and community health nurses.

To establish face validity of the tool in the UP setting, we confirmed with two public health trainers from SIHFW that the objective questions appropriately captured the competencies expected from public health workers, specifically MOs, in UP. Additionally, the refinement of the tool with the help of local experts through translation and back translation partly contributed to achieving the face validity of the instrument. A team from an Indian language services company conducted the initial translation of the tool items into Hindi, followed by a back-translation from Hindi to English by another Indian translator fluent in both English and Hindi languages. Once the translation and back-translation processes were complete, the first author and the members of the research team reviewed these documents to discuss the intent of each item, the literal translation, the commonly understood meaning of the item, and appropriateness of the word choice and phrasing in Hindi as well as English. Overall, the format, wording, and content were deemed suitable for the intended purposes by

the research team. More details about the translation and back translation processes are discussed elsewhere (Paper #2).

Objective measure:

Objective measurement score was generated by: (i) summing up all the correct answers for the individual respondent, (ii) creating the proportion of correct answers by dividing it by the total number of questions (12 of them), and then (iii) rescaling it to 100. Any missing response was handled using multiple imputation.

We also conducted sensitivity analyses where missing values of the objective questions were replaced with worst-case value (missing = 0/wrong answer), best case value (missing = 1/correct answer), and the median value (missing = median). We ran sensitivity analyses to test the robustness and reliability of the results of our primary regression model—the regression model based on multiple imputation. This was particularly important given our small sample size and relatively large standard errors for some of our variables. We then compared the results of the multiple linear regression models in five scenarios: (i) multiple imputation; (ii) complete case analysis; (iii) analysis with missing replaced with worst-case value; (iv) analysis with missing replaced with best-case value; and (v) analysis with missing replaced with median value. We found the results to be similar across these models and decided to stick with our original plan to run multiple imputations for non-responses. We replicated these sensitivity analyses and model comparison process by removing items and respondents with high missing values. We found the results to be similar in this case as well. So, we decided to not remove any items or respondents from our dataset.

We also conducted Exploratory Factor Analysis (EFA) of the objective items to see if we can identify a parsimonious list of factors and generate factor scores. Factor scores were then used for multiple linear regression, which had factors as the dependent variables. The results generated from this exercise were similar to the multiple linear regression that was based on the original objective measure (sum of all correct answers). So, for this study, we decided to use the original objective measure because it is more intuitive and simpler to understand.

Self-assessment tool:

The self-assessment tool included 37 items that relate to broad areas of public health practice, from analysis and assessment, financial management and budgeting, to leadership and communication. See Appendix 23 for the self-assessment competency assessment tool. Respondents self-rated their proficiency in each of these statements by selecting a number between one and four. A score of one (1) meant that respondents were unaware or had very little knowledge of the competency. Four (4) meant they were proficient—they were very comfortable, an expert, or could teach the competency to others.

Self-assessment measure:

The final self-assessment scores used in this study were created at the end of Exploratory Factor analysis (EFA), the analytical process we used for factor extraction and score generation (see Paper #2 for details of EFA). Finalized items from the COPHEC tool were used to generate factor weightings. These final scores—called factor scores—are composite variables that provide information about an individual's placement on the factor identified from the EFA (DiStefano et al., 2009). We then rescaled these factor scores from zero to 100 to use them as finalized self-assessment scores for this study.

4.3.3. Demographic characteristics

As listed in Table 8, we collected information on six demographic variables—sex; duration on the job (years in their current position); duration in the UP health system (years of service in UP health system regardless of the position); education level; public health training received (any in-service non-medical/public health training); and seniority.

Table 8. Variables measured in the study

S.N.	Response vs. predictor variable	Variable	Response options	Variable type
1	Dependent	Objective measurement score	12 standard public health questions	Nominal during survey administration. Converted to continuous for analysis.
2	Independent	Self-assessed competency score	37 self-assessment questions	Categorical during administration. Converted to continuous for analysis.
3	Independent/Demographic variable	Sex	Female, Male	Dichotomous
4	Independent/Demographic variable	Duration on the job	Year and month	Continuous
5	Independent/Demographic variable	Duration in the UP's health system	Year and month	Continuous
6	Independent/Demographic variable	Education level	Bachelors, Master's, Doctorate	Categorical
7	Independent/Demographic variable	Public health training received	Yes, No	Dichotomous
8	Independent/Demographic variable	Seniority	Mid-level, Senior	Dichotomous

4.3.4. Analytical strategy

Data analysis was conducted in two stages— (i) Exploratory Data Analysis and (ii) Bivariate as well as multivariate analyses. We used STATA 14 for all analyses (StataCorp, 2016).

Stage 1: Exploratory Data Analysis

The first stage was the Exploratory Data Analysis (EDA). In this step, descriptive statistics related to the objective as well as self-assessment competency statements were assessed, mostly using measures of central tendencies—mean, median, and mode. The demographic characteristics of the health cadres were assessed across variables like sex, education level, and length of service in the health system.

Stage 2: Bivariate and multivariate analyses

The second step of the data analysis included bivariate and multivariate analyses. First, using the two-sample t-tests, we explored the difference between mid-level health professionals and senior health professionals on self-assessed competencies and objective competencies. The two-sample t-test is useful when testing the hypothesis of equality of means between two independent samples. In this case, our null hypothesis was that the mean self-assessment score for mid-level professionals and senior health professionals are equal. We also hypothesized that mean objective scores are equal for mid-level professionals and senior professionals (Mcdonald, 2009).

Two of the two-sample t-tests were conducted:

<u>Test #1: Mean difference in self-assessment scores</u>

Null hypothesis (H_0): $\mu_{\text{sub}}1 < \mu_{\text{sub}}2$

Alternative hypothesis (H_a): $\mu_{\text{sub}}1 \neq \mu_{\text{sub}}2$, where

$\mu_{sub}1$ = mean self-assessment competency score of mid-level health professionals, and

$\mu_{sub}2$ = mean self-assessment competency score of senior health professionals.

Test #2: Mean difference in objective scores

Null hypothesis (H_0): $\mu_{obj}1 = \mu_{obj}2$

Alternative hypothesis (H_a): $\mu_{obj}1 \neq \mu_{obj}2$, where

$\mu_{obj}1$ = mean objective competency score of mid-level health professionals, and

$\mu_{obj}2$ = mean objective competency score of senior health professionals.

Second, **multiple linear regression was performed to analyze the relationship between objective competencies (dependent variable) with predictors—self-assessed competencies, sex, years of experience on the job, years of experience in the health system, education level, public health training received, and seniority level.**

The final model for multiple linear regression is the following:

$$y_{(\text{objectively measured competency})} = \beta_0 + \beta_{1(\text{self-assessed competency})} + \beta_{2(\text{sex})} + \beta_{3(\text{years on the job})} + \beta_{4\ (\text{education level})} + \beta_{5(\text{seniority})} + \epsilon$$

The variables were coded in the following way: Sex (1= Female, 2 = Male); Education level (1= Bachelors, 2=Masters, 3=Doctoral); Seniority (1=Mid-level, 2=Senior)

4.4. Results

Table 6 presents the demographic characteristics of the respondents disaggregated by the seniority level. A total of 166 health workers responded to the survey. The average self-assessed COPHEC score for senior health professionals was 53, ten points lower than the mid-

level professionals. Interestingly, on average, they scored 54 out of 100 in the objective measurement, compared to the average of 40 for the mid-level professionals.

In terms of the designation of health professionals, among senior staff, the majority were joint directors (67%), followed by the additional directors (15%), and the directors (13%). In the directorate of medical and health and directorate of health and family welfare, directors are ranked higher than Additional Directors (ADs), who are ranked higher than Joint Directors (JDs). Each of the 12 departments (e.g., training, paramedical, nursing) in the directorate of medical and health, and the two departments (family welfare, and maternal and child welfare) in the directorate of health and family welfare typically have one sanctioned director, between one to four ADs, and between one to six JDs.

Almost all (94%) of the mid-level health staff were Medical Officers (MO), and the rest identified as Medical Officer in Charge (MOIC). An MO usually leads a Primary Health Center (PHC) that are located in blocks, which are district subdivisions. PHCs offer basic curative and preventive services, and they form the cornerstone of rural health provision throughout India. They are also the first level in the public system where a physician is present along with supporting health staff. An MOIC usually heads a Community Health Center (CHC), which accepts patients referred from PHCs. CHCs are also located in blocks, but they offer more advanced services (than the PHCs) such as obstetric care and blood storage facilities. An MO usually gets promoted to an MOIC after a few years of work experience.

Figure 8 shows the results of the COPHEC tool. It includes the percentage of participants for mid-level professionals, senior professionals, and for all health professionals.

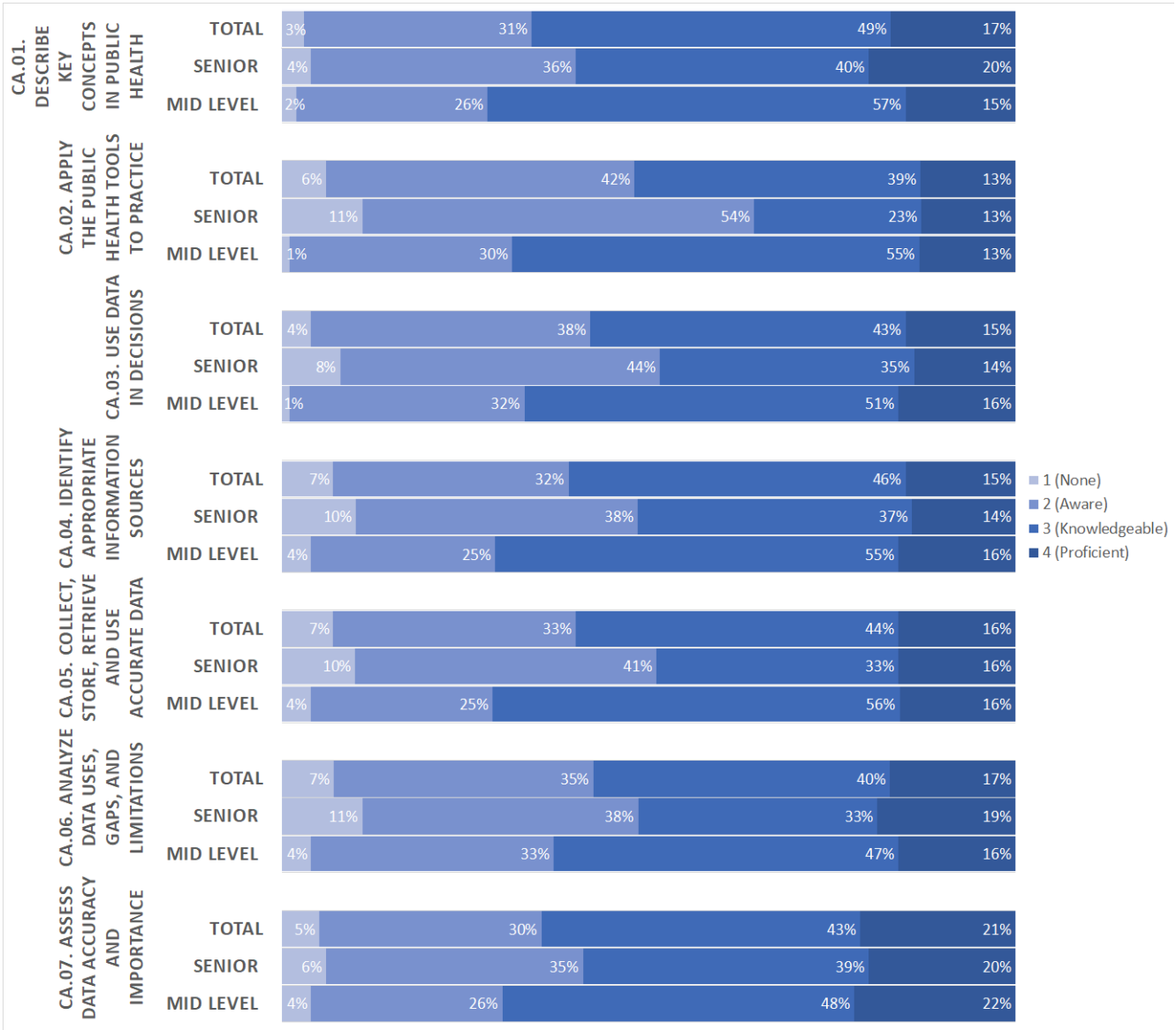
Here are some notable findings. Among mid-level health professionals, 64% self-rated themselves to be knowledgeable (score of 4) in the competency on utilizing public health ethics to manage self, others, information, and resources (item #CA.33). On the other end, 43% said they either had no competency (score of 1) or were only aware (score of 2) about preparing proposals for funding (e.g., foundations, government agencies, corporations) (item #CA.19).

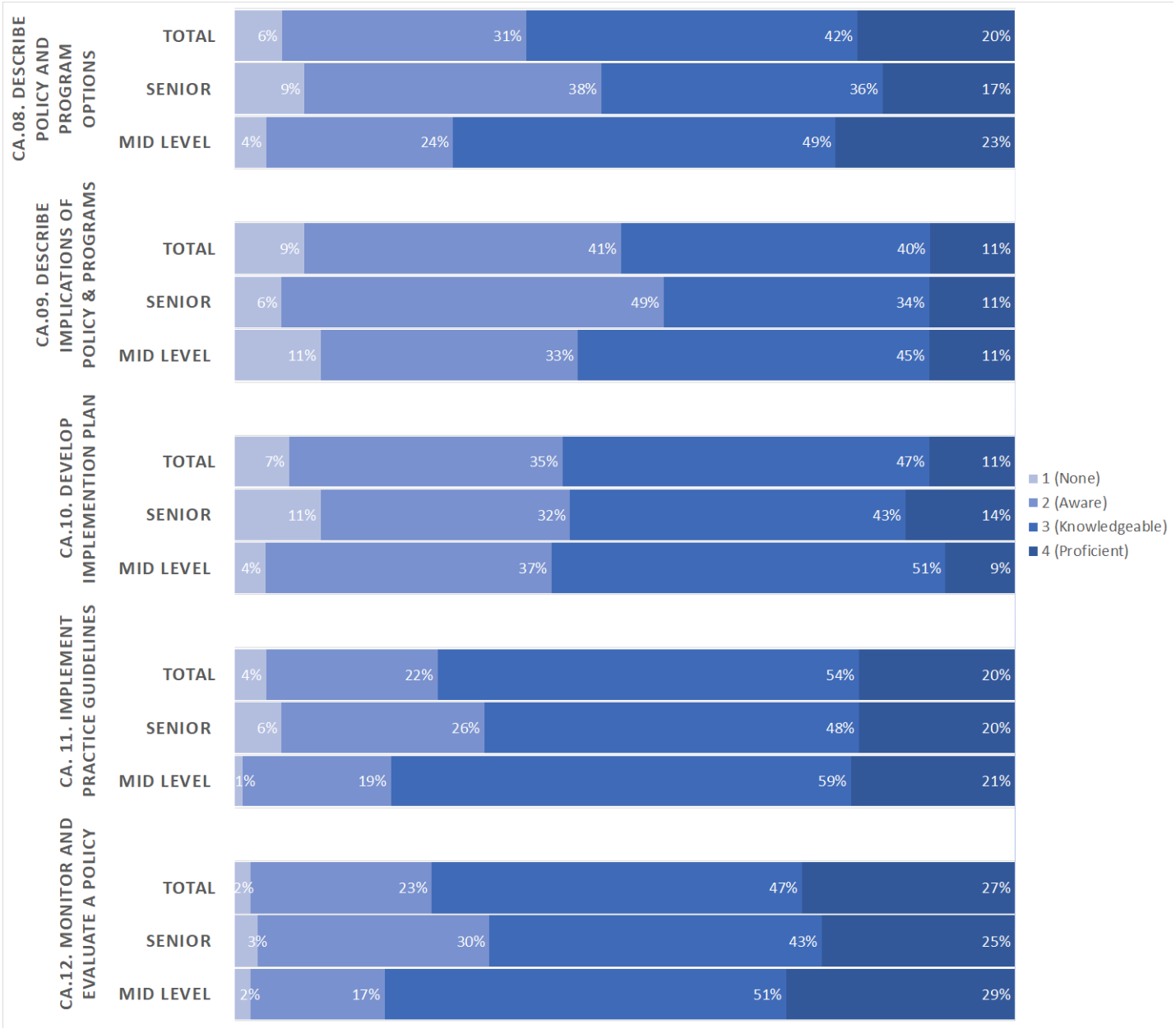
Among senior health professionals, 54% self-rated themselves as knowledgeable (competency score of 2) on maintaining organizational justice, equality, and fairness in dealing with subordinates (item # CA.37). On the other end, almost 60% said they either had no competency (score of 1) or were only aware (score of 2) about preparing proposals for funding (e.g., foundations, government agencies, corporations) (item #CA.19).

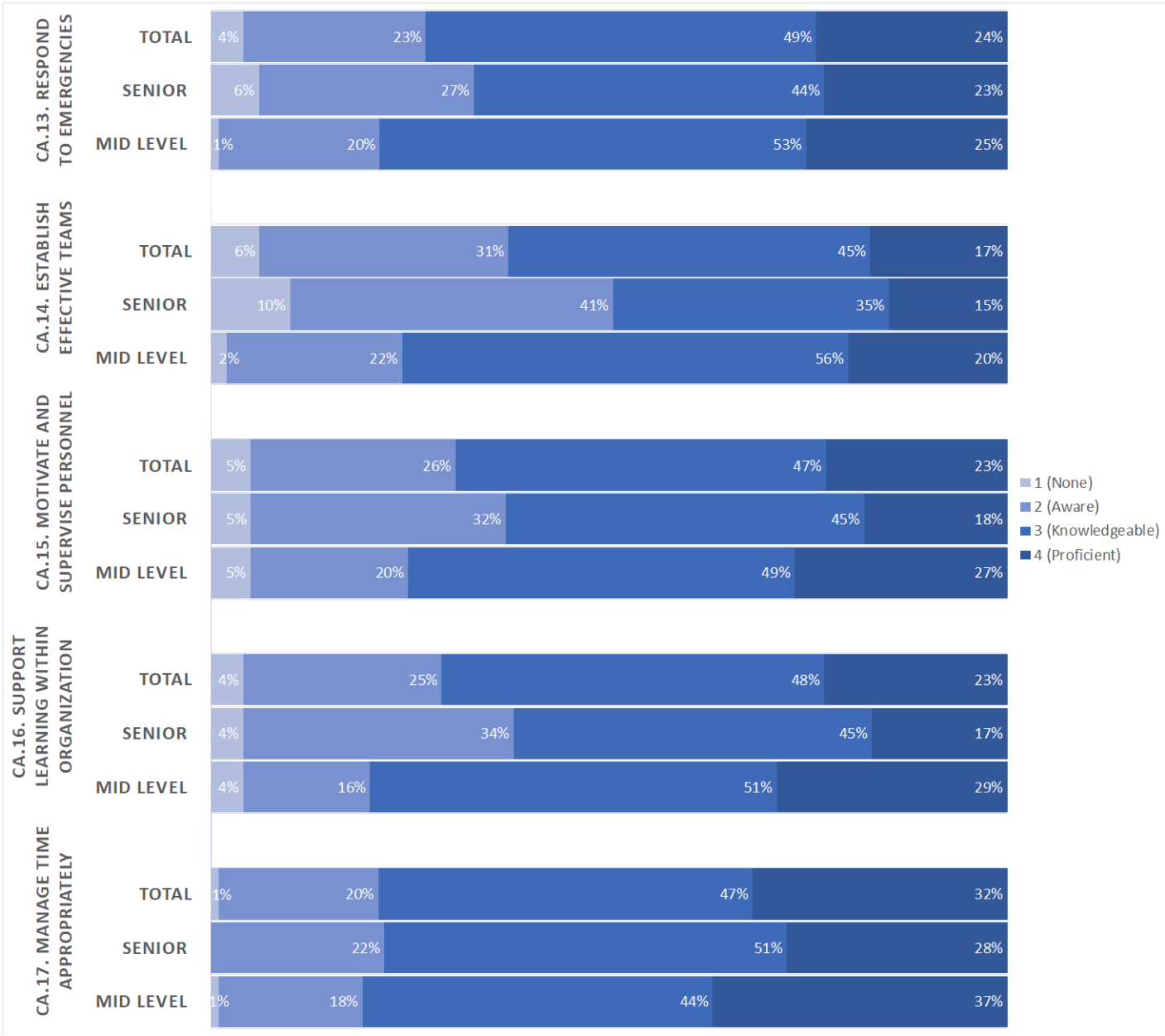
The majority of the respondents self-rated themselves as either aware (competency score of 2) or knowledgeable (score of 3) on a scale of 1 to 4. For all the competency statements, a higher percentage of mid-level professionals self-rated themselves with either knowledgeable (score of 3) or proficient (score of 4) compared to senior-level professionals. The highest difference in the percentage of mid-level and senior professionals scoring either 3 or 4 was on the competency about applying the public health tools, techniques, and sciences to practice (item #CA.02). Sixty-eight percent of mid-level professionals considered themselves either knowledgeable or proficient in this competency, compared to only 35% of senior professionals. On the flip side, the least difference (difference of 2%) between the two groups was found in the competency to manage time appropriately (item #CA.17), with 80% of mid-

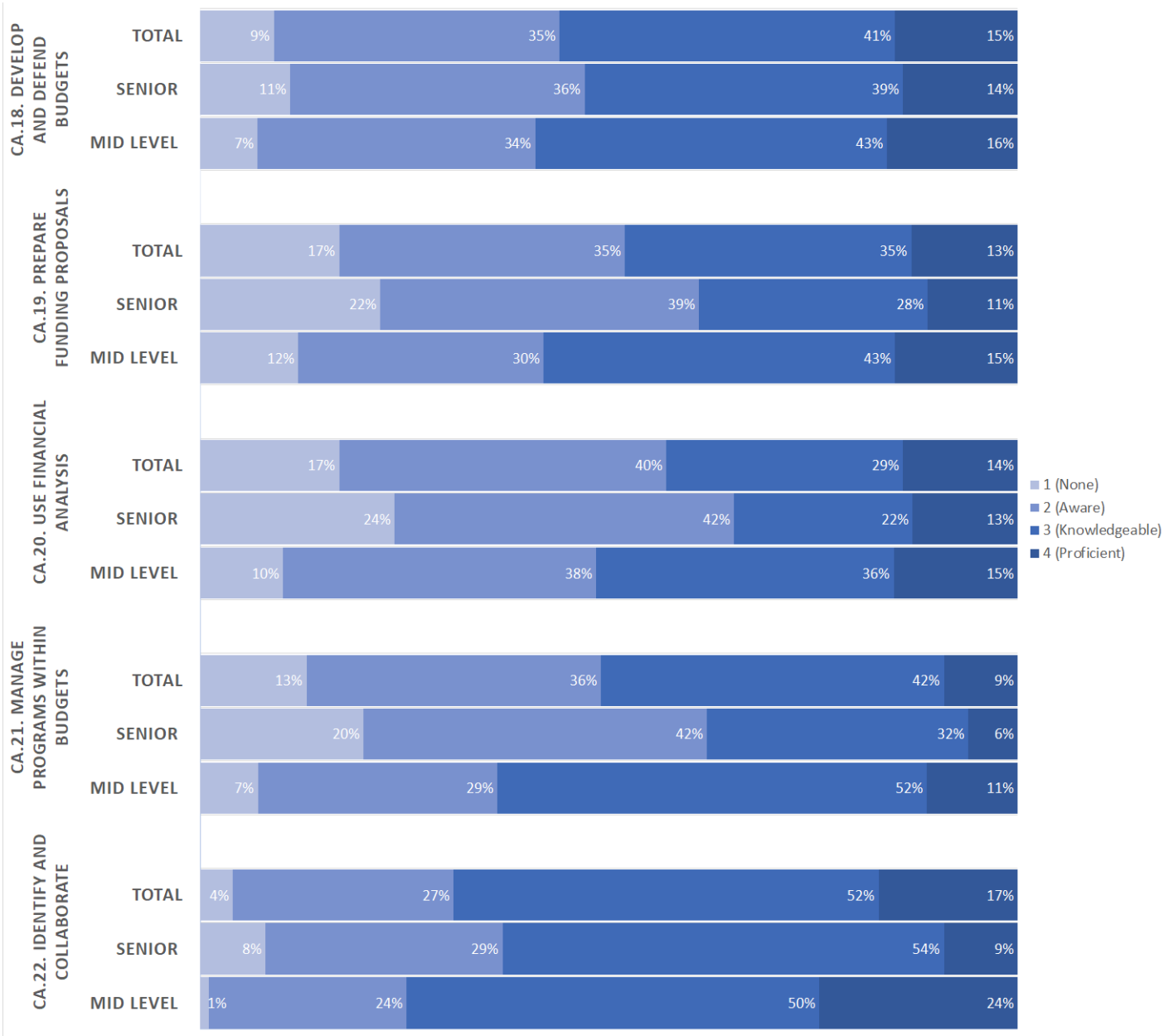
level professionals claiming they are either knowledgeable or proficient in this competency compared to 78% of the senior professionals. On the competency about demonstrating the ability to fulfill functional roles in response to a public health emergency (item #CA.13), 22% of the mid-level professionals and 33% of the senior professionals rated themselves as either having no competency or only aware.

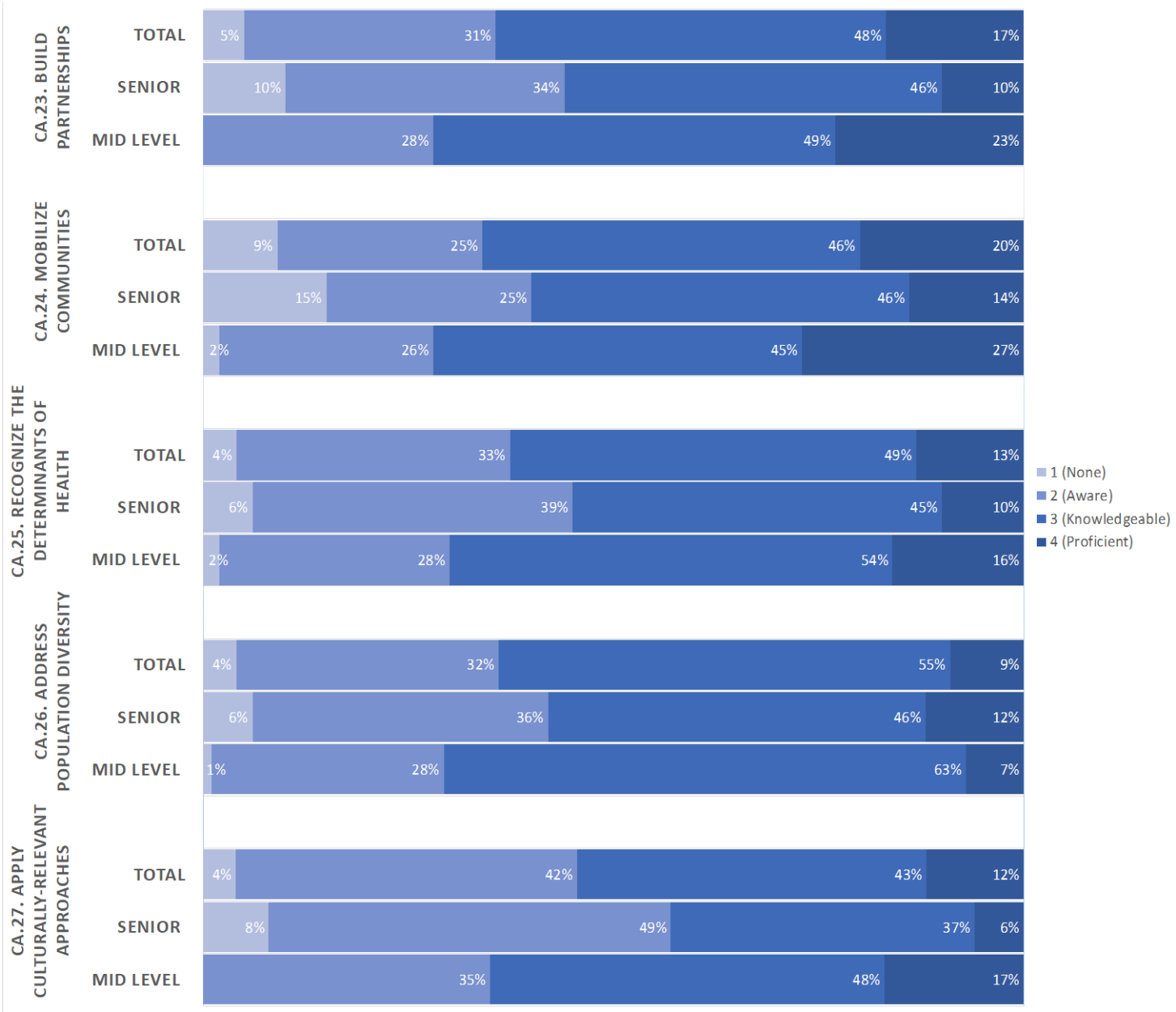
Figure 8. Self-assessed competency levels, stratified by mid-level versus senior professionals for the COPHEC tool

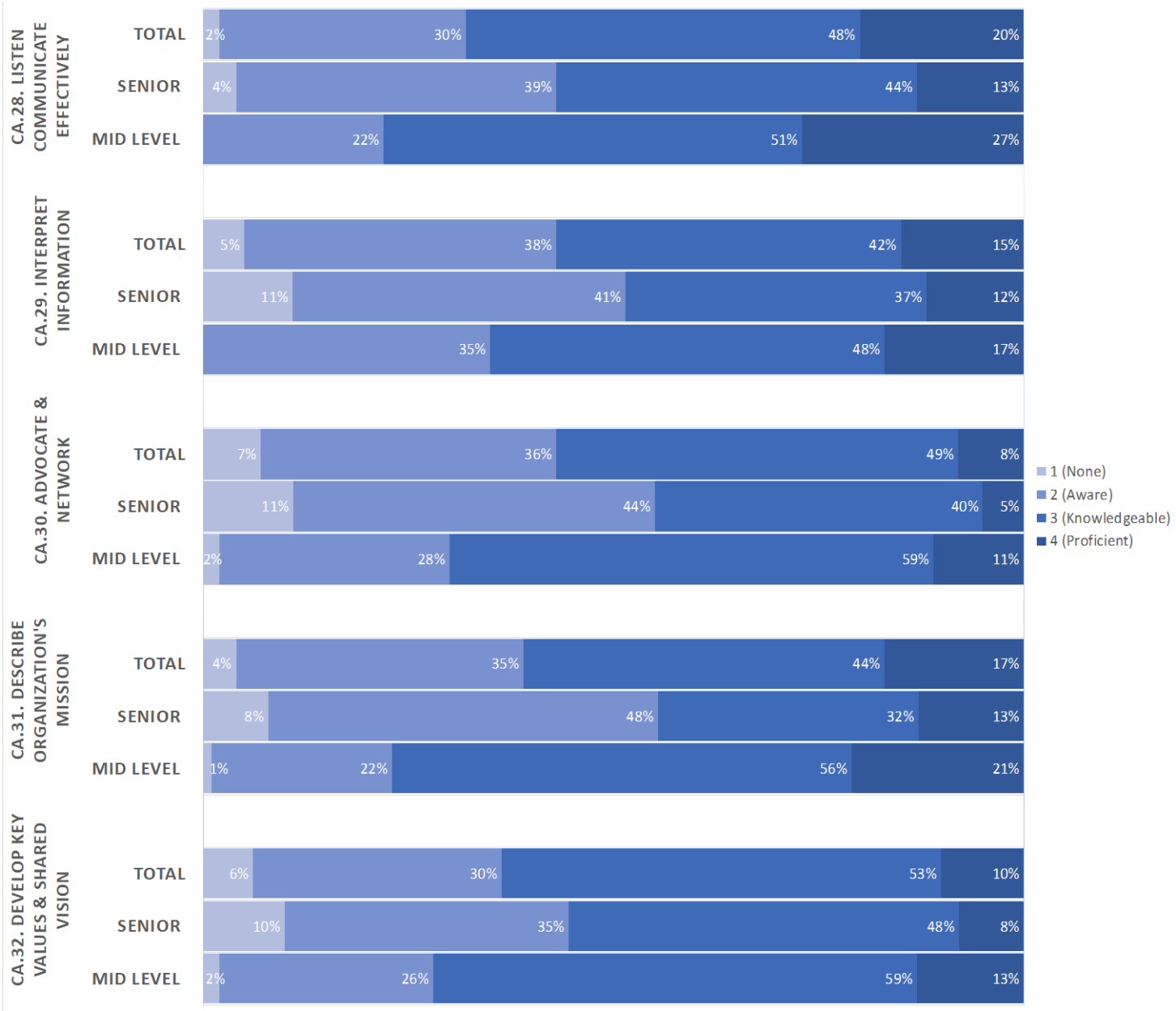



CA.08. DESCRIBE POLICY AND PROGRAM OPTIONS
TOTAL
6%
31%
42%
20%
SENIOR
9%
38%
36%
17%
MID LEVEL
4%
24%
49%
23%
CA.09. DESCRIBE IMPLICATIONS OF POLICY & PROGRAMS
TOTAL
9%
41%
40%
11%
SENIOR
6%
49%
34%
11%
MID LEVEL
11%
33%
45%
11%
CA.10. DEVELOP IMPLEMENTION PLAN
TOTAL
7%
35%
47%
11%
SENIOR
11%
32%
43%
14%
MID LEVEL
4%
37%
51%
9%
CA. 11. IMPLEMENT PRACTICE GUIDELINES
TOTAL
4%
22%
54%
20%
SENIOR
6%
26%
48%
20%
MID LEVEL
1%
19%
59%
21%
CA.12. MONITOR AND EVALUATE A POLICY
TOTAL
2%
23%
47%
27%
SENIOR
3%
30%
43%
25%
MID LEVEL
2%
17%
51%
29%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)


CA.13. RESPOND TO EMERGENCIES
TOTAL
4%
23%
49%
24%
SENIOR
6%
27%
44%
23%
MID LEVEL
1%
20%
53%
25%
CA.14. ESTABLISH EFFECTIVE TEAMS
TOTAL
6%
31%
45%
17%
SENIOR
10%
41%
35%
15%
MID LEVEL
2%
22%
56%
20%
CA.15. MOTIVATE AND SUPERVISE PERSONNEL
TOTAL
5%
26%
47%
23%
SENIOR
5%
32%
45%
18%
MID LEVEL
5%
20%
49%
27%
CA.16. SUPPORT LEARNING WITHIN ORGANIZATION
TOTAL
4%
25%
48%
23%
SENIOR
4%
34%
45%
17%
MID LEVEL
4%
16%
51%
29%
CA.17. MANAGE TIME APPROPRIATELY
TOTAL
1%
20%
47%
32%
SENIOR
22%
51%
28%
MID LEVEL
1%
18%
44%
37%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)


CA.18. DEVELOP AND DEFEND BUDGETS
TOTAL
9%
35%
41%
15%
SENIOR
11%
36%
39%
14%
MID LEVEL
7%
34%
43%
16%
CA.19. PREPARE FUNDING PROPOSALS
TOTAL
17%
35%
35%
13%
SENIOR
22%
39%
28%
11%
MID LEVEL
12%
30%
43%
15%
CA.20. USE FINANCIAL ANALYSIS
TOTAL
17%
40%
29%
14%
SENIOR
24%
42%
22%
13%
MID LEVEL
10%
38%
36%
15%
CA.21. MANAGE PROGRAMS WITHIN BUDGETS
TOTAL
13%
36%
42%
9%
SENIOR
20%
42%
32%
6%
MID LEVEL
7%
29%
52%
11%
CA.22. IDENTIFY AND COLLABORATE
TOTAL
4%
27%
52%
17%
SENIOR
8%
29%
54%
9%
MID LEVEL
1%
24%
50%
24%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)


CA.23. BUILD PARTNERSHIPS
TOTAL 5% 31% 48% 17%
SENIOR 10% 34% 46% 10%
MID LEVEL 28% 49% 23%
CA.24. MOBILIZE COMMUNITIES
TOTAL 9% 25% 46% 20%
SENIOR 15% 25% 46% 14%
MID LEVEL 2% 26% 45% 27%
CA.25. RECOGNIZE THE DETERMINANTS OF HEALTH
TOTAL 4% 33% 49% 13%
SENIOR 6% 39% 45% 10%
MID LEVEL 2% 28% 54% 16%
CA.26. ADDRESS POPULATION DIVERSITY
TOTAL 4% 32% 55% 9%
SENIOR 6% 36% 46% 12%
MID LEVEL 1% 28% 63% 7%
CA.27. APPLY CULTURALLY-RELEVANT APPROACHES
TOTAL 4% 42% 43% 12%
SENIOR 8% 49% 37% 6%
MID LEVEL 35% 48% 17%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)


CA.28. LISTEN COMMUNICATE EFFECTIVELY
TOTAL
SENIOR
MID LEVEL
2%
30%
48%
20%
4%
39%
44%
13%
22%
51%
27%
CA.29. INTERPRET INFORMATION
TOTAL
SENIOR
MID LEVEL
5%
38%
42%
15%
11%
41%
37%
12%
35%
48%
17%
CA.30. ADVOCATE & NETWORK
TOTAL
SENIOR
MID LEVEL
7%
36%
49%
8%
11%
44%
40%
5%
2%
28%
59%
11%
CA.31. DESCRIBE ORGANIZATION'S MISSION
TOTAL
SENIOR
MID LEVEL
4%
35%
44%
17%
8%
48%
32%
13%
1%
22%
56%
21%
CA.32. DEVELOP KEY VALUES & SHARED VISION
TOTAL
SENIOR
MID LEVEL
6%
30%
53%
10%
10%
35%
48%
8%
2%
26%
59%
13%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)

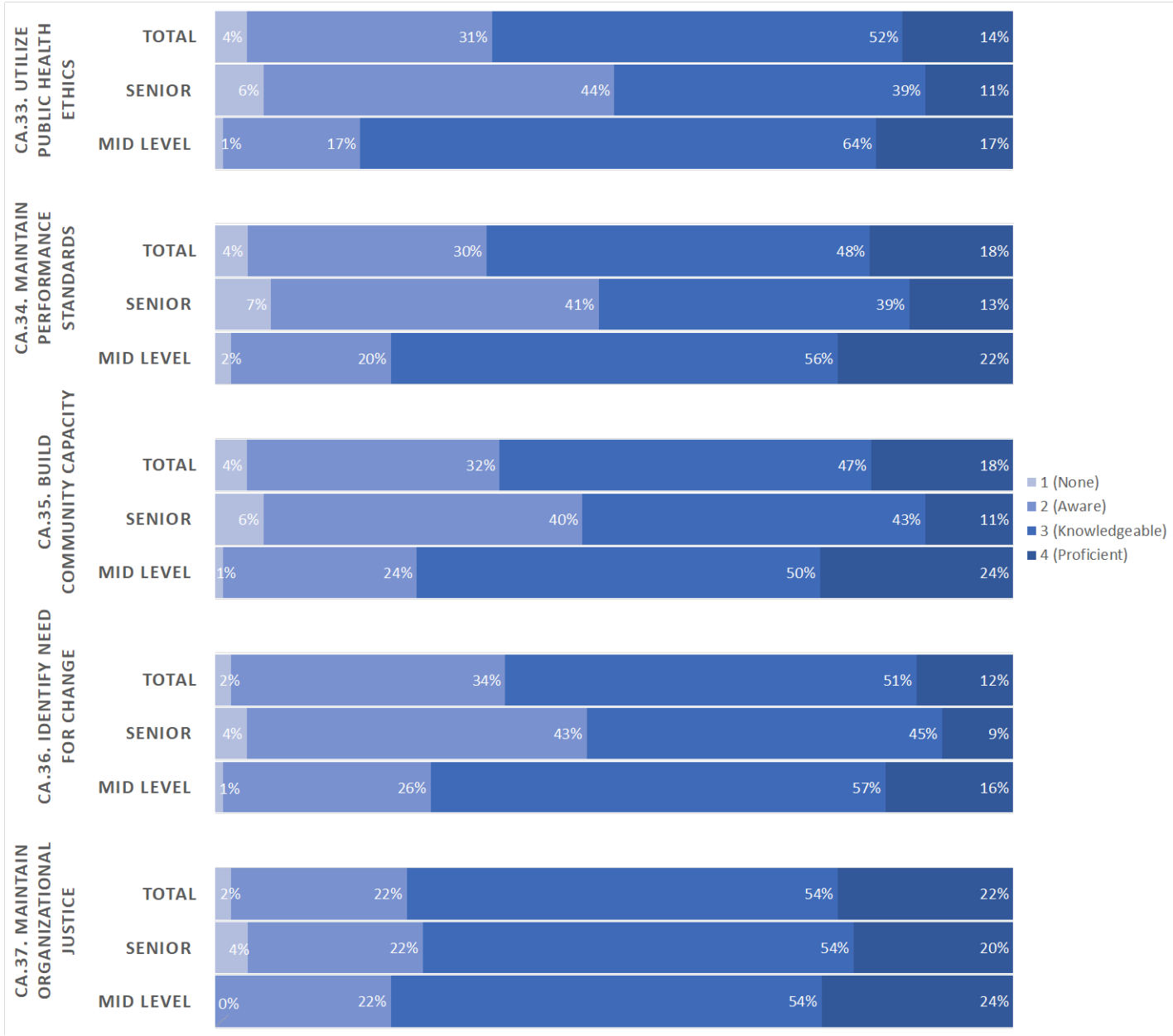

CA.33. UTILIZE PUBLIC HEALTH ETHICS
TOTAL
SENIOR
MID LEVEL
4%
31%
52%
14%
6%
44%
39%
11%
1%
17%
64%
17%
CA.34. MAINTAIN PERFORMANCE STANDARDS
TOTAL
SENIOR
MID LEVEL
4%
30%
48%
18%
7%
41%
39%
13%
2%
20%
56%
22%
CA.35. BUILD COMMUNITY CAPACITY
TOTAL
SENIOR
MID LEVEL
4%
32%
47%
18%
6%
40%
43%
11%
1%
24%
50%
24%
CA.36. IDENTIFY NEED FOR CHANGE
TOTAL
SENIOR
MID LEVEL
2%
34%
51%
12%
4%
43%
45%
9%
1%
26%
57%
16%
CA.37. MAINTAIN ORGANIZATIONAL JUSTICE
TOTAL
SENIOR
MID LEVEL
2%
22%
54%
22%
4%
22%
54%
20%
0%
22%
54%
24%
1 (None)
2 (Aware)
3 (Knowledgeable)
4 (Proficient)

Table 9 shows the results for the objective measurement. It includes the number and percentage of all respondents, along with mid-level and senior professionals, who correctly answered each question. The question type included in the table summarizes the nature of the objective question. The actual questionnaire is listed in Appendix 20.

Here are the most interesting findings. Overall, we found generally low scores on the objective competency assessment for all respondents, but also when stratified among mid-level and senior professionals. Out of 12 questions, only four were answered correctly by more than 50% of all respondents. Similarly, only four questions were answered correctly by more than 50% of the mid-level professionals and only seven were answered correctly by more than 50% of the senior professionals.

Specifically, only 15% of the participants were able to answer the question about judging the appropriate outcome measurement of an intervention to fight drug-resistant TB (question #OA.04). On the flip side, almost 80% of all the respondents correctly answered the question about judging the role of a leader in managing group dynamics (question #OA.08).

Among senior health professionals, the question on classifying a statement about financial management and budgeting (question #OA.12) was correctly answered by 86% of the respondents, compared to 69% of the mid-level professionals. When it came to the identification of the definition for public health surveillance (question #OA.03), only 30% of the senior health professionals were able to choose the correct answer. This was five percent lower than the mid-level professionals—35% of them answered this question correctly.

In 10 out of 12 questions, a higher percentage of senior health professionals correctly answered the objective questions compared to mid-level professionals. The most significant

difference in the percentage of senior and mid-level professionals was on the question about selecting a suitable mix of individuals to develop a public health coalition (question #OA.07). Almost 54% of the senior professionals correctly answered this question compared to only 13% of the mid-level professionals.

Table 9. Results of objective measurement for all respondents, and stratified by seniority

Q#	Question type	Mid-level (N=82)			Senior (N=84)				Total (N=166)		
		Correct response (n)	Total respondents for question	% of correct response	Correct response (n)	Total respondents for question	% of correct response	p-value	Correct response (n)	Total respondents for question	% of correct response
1	Calculating infant mortality rate	24	77	31.17%	40	68	58.82%	<0.05	64	145	44.14%
2	Recommending an appropriate response to a lack of evidence in solving a public health problem	48	79	60.76%	66	80	82.50%	<0.05	114	159	71.70%
3	Defining public health surveillance	28	79	35.44%	24	78	30.77%	0.534	52	157	33.12%
4	Judging appropriate outcome measurement of an intervention to fight drug-resistant TB	12	79	15.19%	12	77	15.58%	0.946	24	156	15.38%
5	Appraising implication of providing culturally appropriate health care	21	78	26.92%	26	79	32.91%	0.413	47	157	29.94%
6	Distinguishing a characteristic of a health system that is based on social justice	30	79	37.97%	40	71	56.34%	<0.05	70	150	46.67%
7	Selecting the suitable mix of individuals to develop a public health coalition	10	79	12.66%	36	67	53.73%	<0.05	46	146	31.51%
8	Assessing the role of a leader in managing group dynamics	58	79	73.42%	68	79	86.08%	<0.05	126	158	79.75%
9	Interpreting the meaning of a compromise in a negotiation	54	80	67.50%	67	80	83.75%	<0.05	121	160	75.62%
10	Distinguishing a systems thinking approach	20	80	25.00%	17	78	21.79%	0.634	37	158	23.42%
11	Classifying a statement about leadership	24	79	30.38%	20	65	30.77%	0.96	44	144	30.56%
12	Classifying a statement about financial management and budgeting	55	80	68.75%	62	72	86.11%	<0.05	117	152	76.97%

Figure 9 and Figure 10 show the correlation between self-assessment and objective measures of competency, overall and stratified by seniority respectively. As Figure 9 shows, there is a negligible positive correlation between self-assessed and objectively assessed competencies (r= 0.07). Figure 10 shows that there is a very low positive correlation strength (r=0.14) for mid-level health professionals and low positive correlation strength (r=0.33) for senior health professionals.

Figure 9. Correlation between self-assessment and objective measurement for all public health professionals

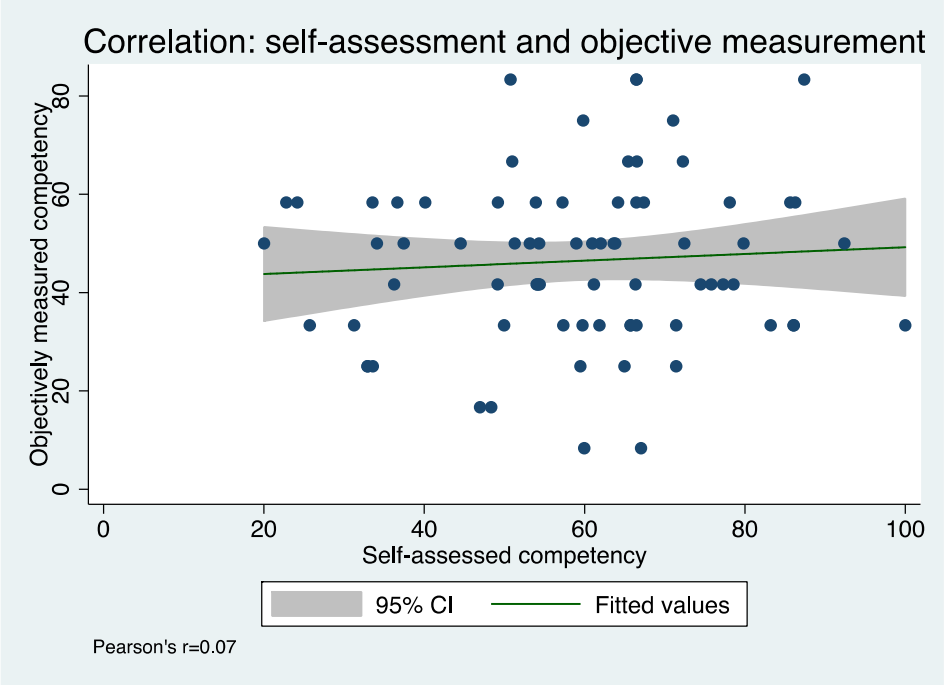


Figure 10. Correlation between self-assessment and objective measurement stratified by seniority

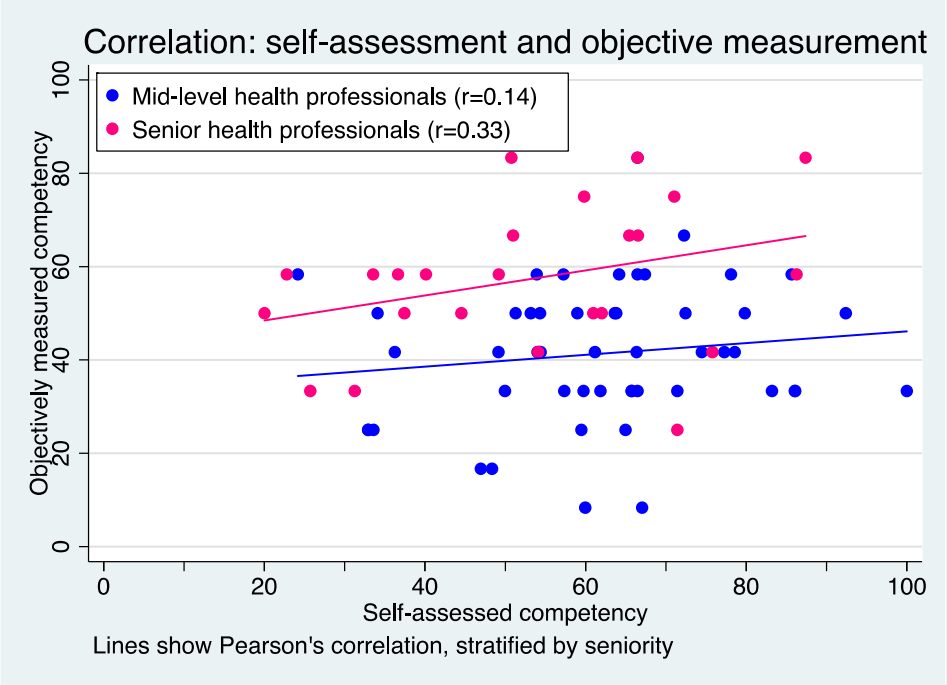


Table 10 shows the results of the two-sample t-tests between mid-level and senior health professionals for self-assessed competencies as well as objective competencies. Mean self-assessment competency scores for mid-level professionals were higher than the senior health professionals. We found this difference to be statistically significant. Interestingly, mid-level professionals scored lower in the objective scores compared to senior professionals. This difference was also statistically significant.

Table 10. Results of the two-sample t-tests between mid-level and senior health professionals for self-assessed competencies as well as objective competencies

Group	Mean	Std. Error	95% Confidence interval	t	p
Self-assessed competencies					
Mid-level	62.10	1.83	[58.45, 65.75]	4.07	<0.05
Senior	50.10	2.30	[45.51, 54.58]		
Objectively measured competencies					
Mid-level	40.00	1.71	[36.59, 43.40]	-5.83	<0.05
Senior	54.14	1.48	[50.20, 56.08]		

Table 11 shows the results of the unadjusted regression models and adjusted regression model (multiple linear regression). Unadjusted regression models showed that education level (doctorate education compared with Bachelor's level) and seniority were positively and significantly related to the objective competency scores ($p<0.05$). The adjusted model (multiple linear regression) showed that seniority is associated with a higher performance on the objective competency test at $p<0.05$. Senior health professionals, on average, scored 13 points higher than the mid-level health professionals, adjusting for demographic variables. Other variables were not found to be statistically significantly associated with performance on the objective test. Specifically, self-assessed competencies correlated poorly with objectively measured competencies, which suggest that public health professionals in this study did not accurately self-assess their competencies (adjusting for demographic factors).

We ended up with this final multiple linear regression model after undergoing numerous iterations, some of which included interaction terms between variables. We decided

on our final model for numerous reasons such as model fit and parsimoniousness. Two variables—public health training and duration of service in UP—were removed from the final model. There was not much variation in these variables, specifically for mid-level professionals. For example, 100% of the mid-level professionals had received some public health training, which meant zero cell count for mid-level professionals who did not receive training. The variable, duration of service in UP was highly associated with another independent variable seniority, indicating multicollinearity. These problems manifested in numerical instability in the model (e.g., drop in significance and change in direction) so we dropped these two variables from our final model.

Table 11. Association between objectively measured competency scores and self-assessed competency scores as well as demographic variables among public health professionals (N=166)

Objective scores	**Simple linear regression results with the objective score as the outcome variable**					**Multiple linear regression results with the objective score as the outcome variable, adjusted for demographic variables**				
	Coef.[a]	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**
Self-assessment scores	0.01	0.06	0.11	0.90	[-0.12, 0.15]	0.11	0.06	1.52	0.13	[-0.03, 0.24]
Sex (1=Female, 2 = Male)	2.54	2.86	0.89	0.38	[-3.10, 8.18]	0.52	2.71	0.19	0.86	[-4.84, 5.89]
Duration on the job	0.76	0.55	1.39	0.17	[-0.32, 1.85]	0.25	0.53	0.48	0.62	[-0.80, 1.30]
Education level 1= Bachelor's level										
2 = Master's level	3.52	6.29	0.56	0.58	[-8.95, 15.99]	0.52	6.06	0.09	0.93	[-11.52, 12.56]
3. Doctorate level	8.07	3.94	2.04	0.04	[0.29, 15.86]	3.23	3.87	0.83	0.41	[-4.43, 10.90]
Seniority (1 = Mid-level, 2 = Senior-level)	12.36	2.34	5.28	<0.05	[7.74, 16.98]	12.63	2.65	4.77	<0.05	[7.39, 17.87]
_cons						19.64	7.29	2.69	0.008	[5.21, 34.09]

[a] All coefficients were produced from separate regression models and correspond to a change in objectively measured competency scores for a unit of change of each independent variable

4.5. Discussion

Our study found generally low scores on the objective measurement of competencies for all respondents, but significantly lower in the mid-level professionals than the senior professionals. Such low performance suggests that a majority of the respondents lack the competency in the areas we measured, and it illustrates significant gaps in competencies to perform public health functions. The findings also show the areas where more public health training is needed, and they provide opportunities to deploy interventions such as competency-based training to address these gaps.

We also found that the self-assessment is only weakly correlated with the objective assessment of core competencies among public health professionals in UP. We found that this relationship remained true even after adjusting for other variables—sex, years of experience in the job, education level, and seniority. The finding suggests that public health professionals in this sample were unable to accurately assess their competencies.

Our finding that self-assessments are poorly associated with objective measurement is similar to studies in other disciplines that have explored this relationship (Gordon, 1991; Ward et al., 2002). Studies in clinical medicine, for example, show a weak relationship between self-assessment and objective competency scores among medical students and physicians. A study by Farrell and colleagues (2010) found a low correlation (r=0.24) between self-assessment measure (faculty's rating of medical students' knowledge) and objective measure (shelf-test—exam based on the topics of clinical rotation like medicine, surgery, and pediatrics) the last day of clerkship of third-year medical students (Farrell et al., 2010). Their finding is similar to the

study by Awad and colleagues. They found that subjective evaluation of medical student knowledge (measured by faculty and senior residents) correlates poorly (r=0.08) with an objective evaluation of student knowledge measured through the National board shelf exam and semi-structured oral exams (Awad et al., 2002). A systematic review of competency measurement among physicians found evidence to suggest that self-assessments are poor predictors of external observations of competencies (Davis et al., 2006). These findings are not unique to clinical medicine. Studies in the fields of guidance counseling, law, engineering, behavioral sciences, psychology, and dietetics all point to low or moderate correlation (mean r of 0.39) between subjective assessment and objective measures of competencies (Boud & Falchikov, 2007; Gordon, 1991; Ward et al., 2002).

Some researchers have claimed that subjective assessment of competencies such as self-assessment is sufficiently capable of discriminating between learners and helping trainers to identify competency gaps (Bose et al., 2001; Parboosingh, 1998; Rosato, F.E., 1972). In low-resource settings where self-assessments might be the only option available for competency measurement, given self-assessment's relative ease in administration and low cost, some assessment information may be better than no information. However, our findings suggest that researchers and policymakers should not rely just on self-assessments to identify public health competency gaps. When possible, objective assessments should be conducted along with self-assessments.

Our study also found that compared to senior-level professionals, mid-level professionals' self-assessments were statistically higher despite having lower objectively measured competencies, perhaps indicating a cognitive bias. This is an interesting finding,

which aligns with research from other fields. This phenomenon of incompetent (or less competent) individuals overestimating their competence has been well documented and explained through the Dunning-Kruger effect. Less competent individuals tend to misjudge their competencies because they are usually not in a position to recognize their cognitive shortcomings. In other words, they do not know what they do not know. The scope of their ignorance is often invisible to them because they lack the expertise and knowledge to recognize how deficient their competence is (Dunning, 2011; Ehrlinger et al., 2008; Kruger & Dunning, 1999).

There may be various reasons why mid-level professionals do not know their competency deficiencies. For example, they may not have been trained properly in the areas we measured. Even though all of them reported receiving some public health training, the quality and length of their training could be inadequate. Also, mid-level professionals may not have had the opportunity to see what good competency (and performance) looks like in their workplaces. They have been working in the UP health system for only around two years, so their breadth of experience is limited. Lack of exposure could mean they are unaware of the competencies they are missing. On the flip side, senior professionals have probably seen some good performance and may have more insights about what they do not know. This may explain the slightly stronger correlation between self-assessment and objective measurement among senior professionals ($r=0.33$) compared to mid-level professionals ($r=0.14$).

The cognitive bias (Dunning-Kruger effect) has implications on performance. For example, a recent study from Senegal found that the clinical health workers who overestimated their skills tended to perform worse when it came to providing quality health care (Kovacs et

al., 2020). In UP, mid-level professionals are in charge of the hundreds of Primary Health Centers (PHCs), and they are at the frontlines of public health provision. Their overestimation of competency and potential underperformance may have implications on the health of millions of UP residents. MOs are faced with a dual burden—not only may their lack of competence lead to mistakes, but their deficits also prevent them from recognizing the limits to their competence.

The obvious next question is—what can we do to address this problem of cognitive bias? Research from other fields such as psychology demonstrates that poor performers can be guided toward more accurate self-assessment (Wason, 1966). Dunning (2011) states, "If [poor performers] misjudge themselves because they do not have the intellectual resources to judge superior versus inferior performance, one has merely to provide them with those resources" (Dunning, 2011). The "resources" to address the cognitive bias can take the form of training programs, which focuses on getting rid of their incompetence. Such a process of educating the poor performers out of their incompetence will lead to them to realize where they were previously incompetent. The challenge with training, however, is that individuals with low competency are unlikely to seek remediation because they have a high level of confidence in their ability (Gross & Latham, 2012). They may not have the motivation to join training programs (Mahmood, 2016). One option to address this lack of motivation might be to make training mandatory. In UP, the pre-service training program at SIHFW is the primary training that provides MOs public health and management training. However, this training is not mandatory, and it is estimated that only 20% of all in-service doctors in the public health system have undergone this training (N. Gupta, 2020; SIHFW, 2018). Policymakers could

consider making this training obligatory so that MOs cannot evade it. However, there is evidence that adults will be better learners if they are motivated to learn, and simply mandating training may not motivate them and therefore could be a waste of time (Gross & Latham, 2012; Mahmood, 2016). Hence, more research is necessary to understand how motivated the MOs are to receive this training, if this training contributes to reducing the cognitive bias, and ways to improve the training if it does not achieve the intended effect.

The other effective approach to addressing the cognitive bias is through feedback about competence, to show employees' their strengths and weaknesses. There is a caveat to feedback as well. The type and design of feedback are important; feedback that is not clear or compelling, but is ambiguous, missing, invisible, or inaccurate tends to have little impact on performance (Dunning, 2014). For feedback to work, it should include the following qualities. It should be accurate. Performance evaluation tends to be affected by leniency bias, in which evaluators tend to rate employees too highly (Woehr & Huffcutt, 1994). Feedback should also be designed to avoid a defensive reaction from the employee receiving the feedback (Audia & Locke, 2003). This can be achieved by ensuring the feedback serves the goal of self-improvement rather than punishment, and that it is frequent and timely. Feedback should also have a follow-up component, where employees are provided a roadmap for improvement to implement change (Locke & Latham, 1990). In UP, feedback for public professionals is provided through the Annual Confidential Report (ACR). It is an antiquated system from the 1940s, in which feedback is provided annually, with little to no opportunity for employees to discuss their performance with their seniors. The feedback is mainly used for promotions, which are mostly based on seniority anyways, rendering the ACR ineffective (McCourt, 2003; Purohit &

Martineau, 2016). There is a need to update the system so that public health professionals understand where their knowledge gaps are, and which in turn reduces their cognitive bias.

Lastly, cognitive bias could be addressed by showing less competent individuals what good performance (in this case, high competency) looks like. This can be done either in a training environment by showing cases of good performance, or in a work environment by recognizing employees who have performed well and setting examples.

Our study also found seniority to be statistically significantly associated with performance on an objective competency test. This finding is intriguing because some of the primary characteristics that distinguish senior professionals from mid-level professionals include years of experience on the job and additional education. Neither of these variables was found to be statistically significantly correlated with the objective score. There may be other explanations for our findings. For example, seniority usually comes with added responsibilities, more authority, and potentially more resources. More authority and resources could mean that they may have more agency to improve their competencies. It could be any one of these variables or an interaction among them that could explain our results. Unfortunately, these variables were not measured in our study. So, further research that quantifies these covariates might be necessary to untangle the relationship between seniority and objective competency performance.

There are a couple of limitations of this study that should be noted. The first is about sampling. The study included a convenience sample of mid-level health professionals. We had approached all the MOs who were present in the training program in Lucknow. We are unable to determine the extent of bias in this sample because we do not know how these trainees

were selected at an individual level by the CMOs. However, we can assume it may be somewhat representative of the population of MOs in their cohort. This is because there is some systematic sampling happening at the district level, as SIHFW cycles through the districts represented in the training program. Regardless, the results from this study should be interpreted cautiously, as findings may not be completely generalizable to the target population of mid-level health professionals.

Another limitation relates to the cross-sectional nature of our study. The causal relationship between the independent variables, such as seniority, and performance on the objective competency test cannot be established. Seniority may have induced higher competency among professionals (for reasons explained earlier), or more competent professionals may have become senior professionals in the first place. This may mean that the health system is good at identifying people who are more competent and promoting them. Or, the finding may also suggest some type of self-section where individuals who are relatively competent at the job stay in the government service and get promoted to the Directorate level, however, those who may be less competent leave for clinical practice. Further exploration of this topic would benefit from studies with longitudinal research design and with additional variables such as self-agency as well as resources to act on competencies.

A third limitation concerns the nature of the objective questions posed. While we sought to find objective questions that were not testing knowledge of terms or 'book knowledge", it is challenging to do this, and some of our findings may relate to the ability to take multiple-choice tests effectively (rather than true competence). While we acknowledge the importance of making this distinction—whether the objective questions were measuring

true competence or respondents' ability to take multiple tests effectively—this is an issue for any questionnaire. This raises the problem of a “reification fallacy”, which relates to the error of treating as a concrete something which is not concrete or merely an idea. In our case, this relates applies to the question of whether our objective measurement test measures competence or the ability to take the test, with all the biases and flaws.

Despite these limitations, we believe that our research provides important insights on multiple fronts, including furthering our understanding of the relationship between self-assessed and objectively measured competencies among public health professionals, advancing knowledge about the Dunning-Kruger effect in public health, and identifying competency gaps that need to be addressed. Our findings and interpretations can be used in multiple ways to improve competencies, such as by revising or developing new training programs to address the competency gaps among these professionals.

Future research should be conducted in the following six areas. First, and most importantly, we need to understand how public health competency relates to the performance of health workers. Previous studies in India have shown that there is a wide gap between health care provider knowledge and performance—the know-do gap (Das et al., 2008; Das & Hammer, 2005d, 2005b; Mohanan et al., 2015). Knowing the extent of this gap among public health workers will help in the design of appropriate interventions to improve health worker performance. It should be noted that people typically cannot perform better than they know how to, so if there were a know-do gap among public health professionals, then it may only increase concerns about the low level of competency.

Second, researchers should explore the effect of training, feedback, and seeing a good performance on competency among public health professionals in UP. As discussed earlier, some of these interventions help correct the Dunning-Kruger effect. However, we do not know of any study that has examined the effect of these interventions among public health professionals in low-resource settings like UP. The goal of such research should be to understand whether these interventions address the lack of knowledge about one's competence, which underlies their cognitive bias. An example of this research is an evaluation of public health training by conducting pre-training assessment and post-training assessment through self-assessment as well as an objective measurement of public health professionals. An increase in the association between self-assessment and objective measurement after training compared to before the training could potentially indicate a reduction of the cognitive bias.

Third, future researchers should measure the relationship between objective measurement and self-assessment for specific competencies rather than overall competencies. This can portray a nuanced picture of the relationship between self-assessed and objectively measured competencies in different facets of public health. Findings from such research can direct future administration of competency assessment tools. For example, if such research demonstrated that self-assessment is a strong predictor of objectively measured competencies in some public health domains (say analysis and assessment), then future competency assessment for that domain need not include objective assessments. This can save valuable time for the survey respondents and financial resources for the survey administrators.

Fourth, researchers should further explore the relationship between self-assessed and objectively measured competencies using larger sample sizes that utilize probability sampling

drawn from the population of MOs in the block level. As discussed in the limitation section, we are unable to determine whether our convenience sample of MOs fully represents the population of MOs in the blocks in UP. So, probability sampling would allow us to be confident in the inferences we make about the population.

Fifth, we need further research to improve the objective instrument. This can involve two approaches—amendment of the existing tool or use of a different method to conduct the measurement. The former approach—amendment—will entail conducting additional validity analyses beyond face validity. This could mean a closer analysis of the questions to evaluate how translatable the questions are in the Hindi language and the Indian context and adding more questions that capture the public health domains.

The latter approach of using different methods to conduct objective measurement can include the use of vignettes and case studies. Vignettes are generally standardized short-answer questions about the treatment or response to a situation presented in written, audio, or video format (Muse & McManus, 2013). For public health competency, this could entail questions that elicit responses about appropriate ways to handle public health emergencies, address lack of evidence on a community health problem, or appraising the implications of providing culturally appropriate care. In medicine, case studies (or case reports) are a detailed written report outlining the symptoms, signs, diagnosis, treatment, and follow-up of an individual patient. They usually describe an unusual or novel occurrence and may be shared with medical, scientific, and educational communities (Kidd & Hubbard, 2007). In public health, case studies could be used to examine the various programmatic, organizational, and policy-related choices that public health professionals face and act upon across various disease

conditions and health care delivery systems (The Case Center, 2020). Compared to MCQs that generally assess the knowledge of the respondents (the first/bottom level of Miller's hierarchy of competency assessment), vignettes and case studies can allow for assessment of "knows how"—the second level of Miller's pyramid in which the respondents can be tested on their skills to apply their knowledge in different contexts.

And lastly, there is more research needed to understand public health competency status at the district-level. Our research provides a lay of the land at the state-level (through the senior professional results) and a glimpse of public health competency status in the blocks (through the MOs). However, we are missing information from the districts—the administrative level between state and blocks. Cadres such as Deputy Program Managers (DPMs) and Chief Medical Officers (CMOs) work in districts. They assume important public health responsibilities that impact large sections of the UP population. So, their competency assessment would be important to develop curated training programs to address any competency gaps we may find. Such an assessment would also be helpful for their performance management.

4.6. Conclusions

Our study found that seniority is statistically significantly associated with performance on an objective measurement of core competency. Overall, objective competency was quite low, but those with senior responsibilities performed better on the test. This perhaps indicates that responsibilities may matter more in ensuring higher competency than time on the seat indicated by duration on the job. Our results also suggest that public health professionals in this

study are unable to accurately self-assess their competencies, as indicated by the low correlation between self-assessment and objective measurement. So, future administration of the COPHEC tool should accompany the objective tool as well. Our findings should prompt reflection on the use of self-rated assessment alone for future competency assessments of health workers in UP and similar settings. This study uniquely contributes to the literature on public health competency assessment and understanding of the Dunning-Kruger effect among public health professionals. We do not know of any study that objectively measures public health competencies of health workers in an LMIC and identifies individual-level factors associated with the assessment results. The findings can be used in multiple ways, including the development of targeted training programs to improve the competencies and in-turn the performance of public health professionals in UP.

5. Conclusion

This dissertation set out to develop a consensus framework that can be utilized to improve the core competencies of public health professionals, to generate a validated and reliable set of items included in a tool to measure core competency in the UP setting, and to explore the individual-level factors that contribute to the performance on an objective core competency test.

The dissertation has fulfilled all of these three objectives. It has developed a core competency framework, which is novel in the UP setting. Most other competency frameworks that have been developed for professional public health cadre are from high-income countries and regions. The dissertation has also generated the core competency assessment tool (COPHEC) index, which includes items that are valid and reliable in the UP setting. While there are tools in the literature to measure competencies of the clinical workforce, an instrument that assesses the core competencies of public health professionals in a resource-poor setting like UP is novel. The dissertation has also helped broaden our understanding of the factors that affect the core competencies of public health professionals. While previous studies have explored this relationship in other disciplines, such exploration has been rare in public health settings.

5.1. Summary of the findings

Using empirical data collected from the state of UP, this dissertation conducted studies that had the following main findings:

First, the framework of core competency for public health professionals identified 48-item and eight domains with adequate statistical stability and agreement. Using a rigorous consensus development approach of the multi-step Delphi technique, we found that in UP, these competencies were spread across eight public health domains: (1) public health sciences, (2) assessment and analysis, (3) policy and program management, (4) financial management and budgeting, (5) partnerships and collaboration, (6) social and cultural determinants, (7) communication, and (8) leadership. Compared to the competencies identified in HICs, the competencies identified in UP differed in their emphasis on policy and program management, which was evident by the number and variety of competencies in this domain. Frameworks from HICs tend to emphasize analysis, assessment, and public health sciences. This difference might be a reflection of the expectations of public health professionals to manage programs in situations of constrained health systems sources, lack of access to essential services, overcrowding of clinics, and medicine shortages. This distinction may also demonstrate the greater need to train public health professionals in management—an important lever to strengthening health systems.

Second, the 37-item COPHEC index, a public health self-assessment tool, includes items that are valid and reliable in the UP setting. Through Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) with the oblique rotation method, we found that the final COPHEC index with 37 items loaded on one factor in the sample. Content and face

validities were assured because the initial set of items for the tool was adapted from the Core Competency framework, which was validated in the UP context. The construct validity of the items in the COPHEC index was confirmed by the high average factor loading of components. The final set of items in the index showed adequate reliability as well.

Third, we also found the seniority of public health professionals to be statistically significantly associated with objectively measured competencies. With the help of multiple linear regression technique, we found that senior health professionals, on average, scored higher on objective assessment than the mid-level health professionals**.** Other variables including self-assessed competencies were not found to be statistically significantly associated with performance on the objective test. We had hypothesized that self-assessment and demographic variables such as the duration on the job, education level, and seniority would have significant positive correlations with the objective measurement. This perhaps indicates that higher responsibilities associated with seniority may matter more in ensuring greater competency than time on the seat indicated by duration on the job. A practically important finding is the identification of generally poor levels of objectively assessed competence among all respondents, but significantly lower in the mid-level professionals than the senior professionals. This result illustrates important gaps in competencies to perform public health functions but also opportunities to deploy measures like competency-based training to address these gaps.

Lastly, we uncovered the issue of cognitive bias, in which poor performers in the objective test were not only deficient in the competencies we measured but also unaware of their deficiency. The findings of the two-sample t-test showed the difference between senior and mid-level professionals in self-assessment as well as objective measurement to be

statistically significant. Mid-level professionals had lower objective measurement scores but higher self-assessment scores than senior professionals. Our null hypothesis was that there is no statistically significant association between self-assessed competencies and objectively measured competencies. Our alternative hypothesis was that these two variables are positively correlated—the higher the self-assessed competencies, the higher the objectively measured competencies. We failed to reject the null hypothesis.

5.2. Contributions of the dissertation

5.2.1. Contributions to existing research, and implications on policies and programs

Despite the extensive breadth and depth of competency literature in the global north, very few studies on the topic exist in South Asia, specifically in India and more so in UP. Our results contribute to the existing literature and knowledge base of identification and measurement of core competencies for practicing public health professionals in India.

We produced a consensus set of core public health competencies and domains in a low-resource setting. While competency frameworks exist for public health professionals in high-income countries and regions, competency identification for professionals who are currently practicing public health in LMICs is uncommon. These competencies can be used for the development and management of human resources for health in low-resource settings. This can be achieved by utilizing the framework broadly to improve recruitment and selection, career development, and performance management of public health professionals in UP. Specifically, the framework can be used to develop functional competencies, inform

competency-based job descriptions, set standards for candidate selection, conduct assessments to identify competency gaps, revise or develop new training programs to address desired competencies, set objectives for an appraisal system, and provide language for feedback on the professional development of public health professionals. These competencies and domains can potentially be adapted for use in other resource-poor settings globally.

The COPHEC index provides the opportunity to measure core competencies in UP, and it can be adapted for use in similar settings elsewhere. The tool can be used by governments in low- resource settings to inform workforce development efforts. Specifically, it can be used by ministries of health to self-initiate the assessment as a way to generate productive discussions around current capacities to meet public health needs, including response to public health emergencies; inform training programs based on competency assessment gaps; evaluate training effectiveness by measuring competency acquisition before and after training; assess the level of competencies among potential recruits to make hiring decisions; improve performance management including the promotion of adequately competent professionals; and incentivize in-service training programs to improve certain competencies among health workers.

This dissertation also contributes to our understanding of the relationship between self-assessment and objective assessment of core competencies among public health professionals. Our results suggest that public health professionals in this sample were unable to accurately assess their competencies, demonstrated by the finding that self-assessment scores are poor predictors of objectively measured competencies. This relationship remained true even after adjusting for variables like gender, years of experience, education level, and public health training. While previous research in many fields including clinical medicine, counseling,

law, and psychology have shown poor correlation between these two measures, this association has rarely been tested among public health professionals.

And lastly, **this dissertation uncovered the phenomenon of the Dunning-Kruger effect in public health in this context.** We found that while mid-level professionals were less knowledgeable about public health compared to senior health professionals, their self-assessment competency scores were higher, perhaps indicating a cognitive bias. This phenomenon could be explained by the Dunning-Kruger effect, in which less competent individuals are not only deficient in their competencies but also unaware of their deficiency. Less competent individuals tend to misjudge their competencies because they are usually not in a position to recognize their cognitive shortcomings. The scope of their ignorance is often invisible to them because they lack the expertise and knowledge to recognize the deficiency of their competence. While there are studies of this phenomenon in other fields like clinical medicine, it has rarely been explored in public health. This finding suggests the need to provide poor performers in the test with appropriate training, feedback, and opportunities to see as well as experience what good performance (high competency) looks like. These interventions could help the poor performers get the knowledge to recognize the limits of their competencies, which can help them in addressing the competency gaps.

5.2.2. Contributions to the conceptual framework and theoretical understanding of core competency development process

Apart from the aforementioned contributions, which are related to three distinct research papers that comprised this dissertation, our research has provided insights into the conceptual framework described in Chapter 1. We found that the relationship between some of

the individual factors and competency may not be as strongly related or linearly associated, as conceptualized in the framework. For example, the duration on the job was considered to be an important predictor of competencies. On the face value, this relationship seems reasonable; employees gather more knowledge and skills the more time they spend on their jobs. However, our research findings demonstrate that such a linear connection may be too simplistic to accurately describe the impact of experience on competencies. It could be that employees who have spent a longer duration in the same job hit a competency ceiling, where they do not gain any additional competency with additional time spent in their position. In some cases, competencies might deteriorate over time if employees are unable to use them regularly. A similar explanation might account for our findings that describe the relationship of competency with education. We found receiving more formal education was not statistically significantly correlated with objectively measured core competencies. So, the framework could be refined in the future to investigate the nuances of the relationship among these variables.

There are many aspects of the framework that remain unexplored in this research. For example, we did not measure the organizational environment including the firm's culture and climate, and some individual factors such as motivation and worker values. The dissertation leaves open opportunities also to advance our understanding of how these various pieces interplay to contribute to health worker performance, health systems performance, and their impact on health outcomes.

While we were able to contribute to our understanding of the relationships among variables in our conceptual framework, we have also identified an important theoretical gap related to the core competency development process, which is relevant for researchers in UP and elsewhere. Core competency frameworks often have to grapple with being broad enough

to be comprehensive but also targeted enough to be relevant for all professionals; while the frameworks are meant to apply to all workers in the public health system, they are also expected to be relevant to every professional in the system. However, the public health sector includes many different positions with various responsibilities and expectations. The breadth of the public health profession is so wide (and at times undefined), there is confusion as to who the target audience of the framework should be. Such confusion is described by a recent study by Bornioli et al. that evaluated the UK's public health competency framework. As one interviewee in the study aptly asked, "Is [the framework] supposed to cover up to the specialist level? That is a massive breadth of practice. That's a bit like in education trying to have a curriculum that covers everything from GCSE up to doctorate…" (Bornioli et al., 2020).

Some countries have attempted to address this challenge by dividing the core competency framework for different tiers of public health professionals. For example, the United States has split the core competency framework into three tiers—entry/frontline, program management, and executive/senior management. Such demarcation of public health professionals, however, can be arbitrary and inapplicable to other settings. More importantly, there is such a wide variation of roles within each of these levels that a simple partition is unlikely to solve the need for targeted competencies. Our framework faces a similar challenge—it aims to cover the mid-level professionals which include public health professionals from community health workers to senior directors in the Ministry of Health. This description includes professionals like MOs who are usually in charge of primary health care centers at the block level to District Program Managers (DPMs) who work in the district health office and are in charge of public health programs for the entire district.

We propose two major ways to address this issue. The first relates to how we envision the core competency framework to be used. Core competencies are meant to include foundational or crosscutting skills for all individuals working in public health. The onus then falls on the user—policymaker or educator—of the framework to understand the importance of individual core competency to a specific position as they may vary depending on the position. The user should evaluate the types of positions and career trajectories when planning competency-based professional development to ensure that an organization collectively has the strengths across these competencies. So, the framework should not be considered set in stone, but rather a flexible document that end-users can utilize to address their specific needs. Relatedly, the core competency assessment tool should be calibrated to the level expected for different types of health workers or the positions they fill.

The second way to address this issue could be by identifying functional competencies. While core competencies broadly define the knowledge, skills, abilities, and attitudes for all health professionals regardless of their discipline in a health system, functional competencies are discipline-specific and can build on core competencies. Functional competencies can be developed for groups of professionals like epidemiologists, public health nurses, and public health informaticians.

5.3. Future research direction

The results of the three papers within this dissertation presented the nuance of the identification and measurement of core public health competencies. Furthermore, it shed light on the complexity of what makes up the concept and how to go about measuring it. Based on the findings of the papers, three major future research directions are identified below.

The first area of future research includes further exploration of the phenomenon of competency. Researchers should examine how competencies translate into performance and assess the roles of workplace culture and individual motivation in the relationship between competency and performance. Previous studies in India have shown that there is a wide gap between provider knowledge and performance, the know-do gap. Knowing the extent of this gap among public health workers will help in the design of appropriate interventions to improve health worker performance. Additional research is also necessary to understand how individual competencies contribute to not just individual health worker performance but the team, organizational, and health systems performance in low- and middle- income settings.

Statistical models that explore competency's determinants like the length of service and gender should also be investigated in larger samples and in other low-resource settings. Further research is necessary to understand the barriers and enablers of core competency demonstration in the workplace, and the most effective strategies (including training) for strengthening and sustaining public health competencies. Researchers could also delve deeper into a particular competency domain, for example, management or leadership, to gain additional understanding of how competencies in these areas connect with other measures like workplace culture and motivation.

There is a need for similar competency research in the district and block levels throughout the state to understand competency gaps among health cadres at those levels. Most of the research described in this dissertation was based on the data collected at the state level. The IRB approvals and government authorization have already been received for competency assessment research in the block and district levels in UP. That study was halted because of the COVID-19 pandemic. We are planning to conduct one cross-sectional survey at the district level to assess public health competencies among 600 public sector health workers across 50 districts in UP, and another cross-sectional survey at the block level among 650 public sector health workers working in block-level facilities across these 50 districts. See Appendix 7 for the details of these planned activities.

The second broad area of future research includes calibration of the self-assessment tool and further exploration of how self-assessment relates to objective measurement. Confirmatory factor analysis in other samples in UP or similar settings can be conducted to confirm the factor structure of the COPHEC index. Also, exploratory factor analyses can be used to revise the COPHEC instrument in new settings. These studies should rely on probability sampling to ensure that the results are generalizable to the target population.

Researchers should also explore the relationship between self-assessed and objectively measured competencies using larger sample sizes that utilize probability sampling drawn from the population. As discussed in the limitation section of the third paper, we are unable to determine whether our convenience sample of MOs fully represents the population of MOs in the blocks in UP. So, probability sampling would allow us to be confident in the inferences we make about the population.

Future research should explore if there is a response to training, feedback, and seeing a good performance on competency among public health professionals in UP. Some of these interventions can help correct the cognitive bias (Dunning-Kruger effect), in which less competent individuals are ignorant of the deficiencies of their competencies. However, we do not know of any research that explores this question in the field of public health in low-resource settings like UP. The goal of such research should be to understand whether these interventions address the lack of knowledge about one's competence, which underlies their cognitive bias.

Future researchers should also consider measuring the relationship between self-assessment and objective measures for specific competencies in a particular domain, say analysis and assessment, rather than overall competencies. This can portray a nuanced picture of the relationship between self-assessment and objective measurement in different facets of public health. Findings from such research can direct future administration of competency assessment tools. For example, if such research demonstrated that self-assessment is a strong predictor of objectively measured competencies in some public health domains (say analysis and assessment), then future competency assessment for that domain need not include objective assessments. This can save valuable time for the survey respondents and financial resources for the survey administrators.

The third area of future research includes exploration of the practical applications of competency measurement. Researchers can conduct studies to analyze the feasibility of incorporating competency assessments as a part of licensure and accreditation requirements for public health professionals. Continued accreditation and licensure are routine practice in many fields like aviation and clinical medicine. They can help standardize the profession and

require professionals to continuously improve and remain up to date with the latest scientific and technological changes. It would be important to explore the capacity, authority, and accountability of different government agencies in UP and other low-resource settings to undertake the licensure and accreditation efforts. Researchers could explore the feasibility of incorporating technology, including digital badges, to streamline the licensure process. They can also explore the impact of competency acquisition and licensure on job satisfaction and retention of public health professionals.

Future research should also incorporate longitudinal and repeated cross-sectional designs to monitor how competencies change over time. Conducting periodic assessments has many programmatic advantages. For example, it can help gauge how long the improvements in competencies achieved through interventions like training can be sustained and what factors contribute to such sustenance. Results from such research can inform the nature of programmatic interventions, including the frequency of in-service training programs.

There are a few practical areas of further research that are feasible to be conducted immediately. For example, researchers can map existing job descriptions for public health professionals in UP to the competencies we have identified. The results of such mapping exercise can help in amending job descriptions, making them more competency-based, and assisting in recruitment efforts such as candidate screening and interviewing. Researchers can also generate a crosswalk that connects the EPHFs of UP to the competencies. Such an exercise can help develop the public health skills needed for assuring the delivery of these functions.

The framework we have generated is applicable mostly for mid-level public health professionals, and we extended it to include senior-level officials as well. More work is necessary to develop a similar core competency framework and assessment tool for the

frontline staff members such as Accredited Social Health Activists (ASHAs) and Anganwadi workers. Researchers can do that by extending and adapting the framework as well as the tool from this dissertation, and with the expert input from stakeholders from UP and more broadly in India.

Lastly, researchers should aim to understand the feasibility of incorporating competencies in human resource planning and development in a low-resource setting like UP. They should analyze the practicality, using methods like political feasibility analysis and economic evaluation, of interventions such as competency-based human resource planning. Competency-based human resource planning approach is helpful for planners who have to make the optimal use of constrained human resources, by allowing them to move beyond simply estimating numbers of certain professionals and plan instead based on a unique mix of competencies available from current health cadres (Tomblin Murphy et al., 2013). Researchers should also examine how competencies can inform the development of public health cadre. Indian national health policy 2017 has encouraged the states to create a separate public health cadre (Ministry of Health and Family Welfare, 2017). As UP considers developing its own set of public health cadres, it would be important to explore how the framework, tool, and measurement findings of this dissertation can support the development of such cadre to eventually improve health outcomes of the state.

Appendices

Appendix 1. Selected definitions of competency and their sources

Author	Discipline	Definition
(McClelland, 1973)	Management	Competencies are components of performance associated with "clusters of life outcomes". This definition views competencies broadly as any psychological or behavioral attributes associated with success.
(Hayes, 1979)	Management	A generic knowledge, motive, trait, social role, or skill of a person linked to superior performance on the job.
(Boyatzis, 1982)	Management	A person's set of competencies reflect his or her capability. They are describing what he or she can do, not necessarily what he or she does.
(Albanese, 1989)	Management	A personal characteristic that contributes to effective managerial performance.
(Woodruffe, 1993)	Management	A competency is the set of behavior patterns that the incumbent needs to bring to a position in order to perform its tasks and functions with competence.
(Spencer & Spencer, 1993)	Management	Competences are motives, traits, self-concepts, attitudes or values, content knowledge, or cognitive or behavioral skills—any individual characteristic that can be measured or counted reliably and that can be shown to differentiate significantly between superior and average performers, or between effective and ineffective performers
(World Health Organization & Regional Office for the Western Pacific, 1993)	Nurse managers and nurse educators	Competence is the ability to effectively and efficiently deliver a specified professional service. This implies that the nurse is able to practice at a proficiency (mastery of learning) in accordance with local conditions to meet local needs.
(Mirabile, 1997)	Management	Knowledge, skill, ability, or characteristic associated with high performance on a job such as problem solving, analytical thinking, or leadership.
(Athey & Orth, 1999)	Human Resource practice	A set of observable performance dimensions, including individual knowledge, skills, attitudes, and behaviors, as well as collective team, process, and organizational capabilities, that are linked to high

		performance, and provide the organization with a sustainable competitive advantage.
(United Nations, 2002)	Human resource practice	The term “competency” refers to a combination of skills, attributes, and behaviors that are directly related to successful performance on the job.
(Institute of Medicine, 2004)	Health professional education	Competencies are defined here as the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values, and reflection in daily practice.
(World Health Organization, 2011)	Sexual and reproductive health providers	Competency refers to sufficient knowledge, psychomotor, communication, and decision-making skills and attitudes to enable the performance of actions and specific tasks to a defined level of proficiency.
(Royal College of Physicians and Surgeons of Canada, 2012)	Physicians	Competency is an observable ability of a health professional related to a specific activity that integrates knowledge, skills, values, and attitudes. Since competencies are observable, they can be measured and assessed to ensure their acquisition.
(International Pharmaceutical Federation, 2012)	Pharmacists	Competencies are the knowledge, skills, behaviors, and attitudes that an individual accumulates, develops, and acquires through education, training, and work experience.
(World Health Organization, Regional Office for Africa, 2014)	Nurses	Competency is the basic knowledge, skills, attitudes, and judgement required to safely perform the prescribed role.
(World Health Organization, 2015)	Primary care providers	Competency is sufficient knowledge, psychomotor, communication, and decision-making skills and attitudes to enable the performance of actions and specific tasks to a defined level of proficiency.
(Ajuebor et al., 2019)	Health preventing antimicrobial resistance	Competency is a “combination of knowledge, skills, motives and personality traits”, development of which should help individuals to continually improve their performance and to work more effectively.

Appendix 2. Description of competency assessment methods

Competency assessment method	Level of competency assessment (Miller's framework)[§§§]	Description
Essays	Level 1	Essays allow respondents to provide contextualized answers than MCQs and require effortful retrieval of information to construct an answer. They usually entail a prompt or question designed to assess both the ability to present written debate and to communicate with professional colleagues (Epstein, 2007; Schuwirth & van der Vleuten, 2004; Wass, McGibbon, et al., 2001).
Health professional self-assessment	Level 1	Self-assessment is the ability of a health worker to reflect on his or her own performance strengths and weaknesses to identify learning needs, conduct a review of his or her performance, and reinforce new skills or behaviors to improve performance (Kak et al., 2001).
Multiple-choice questionnaire (MCQs)	Level 1 or Level 2	MCQs usually entail a lead-in statement or question followed by several responses, from which one or more correct answer(s) is selected (Muse & McManus, 2013). MCQs could be used to construct questions (e.g., short answer) to demonstrate skills. They can also require interpretation or synthesis and not just recall.
Vignettes	Level 2	Vignettes are generally standardized short-answer questions about the treatment or response to a situation presented in written, audio, or video format (Muse & McManus, 2013). For public health competency, this could entail questions that elicit responses about appropriate ways to handle public health emergencies, address lack of evidence on a community health problem, or appraising the implications of providing culturally appropriate care.
Case reports	Level 2	In medicine, case reports are a detailed written report outlining the symptoms, signs, diagnosis, treatment, and follow-up of an individual patient. They usually describe an unusual or novel occurrence and may be shared with

[§§§] Level 1-knows; Level 2-knows how; Level 3-shows how; Level 4-does

		medical, scientific, and educational communities (Kidd & Hubbard, 2007). In public health, case studies could be used to examine the various programmatic, organizational, and policy-related choices that public health professionals face and act upon across various disease conditions and health care delivery systems (The Case Center, 2020).
External observation	Level 2	Observations in which enumerators sit with providers for some time (typically a day) and record various attributes of every interaction (Russler, 2009). For public health competency, this could involve external evaluators sitting with public health professionals as they communicate with community members to address public health issues; within the organization during planning, adapting, and evaluating public health programs with colleagues; or during team-building exercises to build partnerships with other stakeholders.
Role-plays	Level 3	Role-plays are artificial simulations of scenarios in which a professional interacts with an individual playing the role of a standardized patient. The providers' ability to carry out performance-based tasks within the role-play is then rated by an observer, either via 'live' observation or from a recording, using pre-defined criteria (Joyner & Young, 2006). In public health, this can involve an individual role-playing a customer—for example, a community member—in various public health scenarios such as a village meeting to address a disease outbreak. The public health professional could be rated on various competencies such as their ability to appropriately respond to community demands for more action, skill to mediate between differing interests, or ability to communicate effectively about evidence and research.
Chart abstraction	Level 3	Patient charts are maintained by providers and assessed and graded by expert teams, providing an important way to measure quality (Luck et al., 2000; Peabody et al., 2000). For public health competency, this may include document reviews, and interviews with the stakeholders about specific actions that a public health professional took

		during, say, a public health crisis. Experts could rate the response across measures such as professionals' ability to collect and use accurate data, to develop a plan to implement a course of action, motivate and supervise their team members to achieve program goals, etc.
Patient outcome	Level 4	While it is not directly a measure of competence of the professional, patient outcome data can be used to infer the competence of the professional (Benner, 1982). For public health competency, this may entail inferring competencies from health outcome data of a community or population. However, one needs to be careful about making such inferences due to ecological fallacy—the error in reasoning that arises when inferences are made about individuals based on aggregate level data for a group (Schwartz, 1994).
Supervisory assessments	Level 4	Supervisory assessments of provider competence are completed retrospectively based on the supervisor's observation of the provider's performance in supervision over an extended period (Townend et al., 2002).
Patient surveys	Level 4	Patients' evaluation/perception of the services received; may also be used to assess the provider's competence (Muse & McManus, 2013). For public health competency, this may entail administering surveys among community members who receive services from the frontline public health staff or population-level survey to examine perceptions of a health department.

Adapted from: (Muse & McManus, 2013)

Appendix 3. Types of competency and their definitions

Competency type	Definition
Behavioral competency	"Soft skill" that is associated with underlying characteristics of individuals (such as motive, traits, skills, aspects of one's self-image) (Boyatzis, 1982; Spencer & Spencer, 1993).
Cognitive competency	"Personal characteristics of cognitive processes that enable appropriate resource integration" (Takenaka et al., 2020).
Core competency	Key skills, knowledge, abilities, and attitudes that differentiate an individual or organization from their competitors. A term coined in 1990 by Prahlad and Hammel to describe the set of technologies, methodologies, strategies, or processes of an organization that creates a competitive advantage in the market. An organization's core competency is the organization's strategic strength (Prahalad & Hamel, 1990).
Cultural competency	"A set of congruent behaviors, attitudes, and policies that come together in a system, agency, or among professionals that enables effective work in cross-cultural situations."(Centers for Disease Control and Prevention, 2015)
Emotional competency	"Learned capability based on emotional intelligence which results in an outstanding performance at work"(Goleman, 1999).
Functional competency	Job-specific competencies that drive proven high-performance, quality results for a given position. While core competencies may be applicable for all jobs in a particular organization, functional competencies vary between roles in a job family. They are often technical or operational in nature (e.g., "conducting epidemiological surveillance" is a functional competency) (Cheetham & Chivers, 1996).
Management competency	Management competencies identify the specific attributes and capabilities that illustrate an individual's management potential.
Meta-competencies	"Meta-competence is the overarching ability under which competence shelters. They are the higher-order abilities that have to do with being able to learn, adapt, anticipate, and create. Meta-competences are a pre-requisite for the development of capacities such as judgment, intuition, and acumen upon which competencies are based and without which competencies cannot flourish."(Brown & McCartney, 1995)
Organizational competency	The mission, vision, values, culture, and core competencies of the organization that sets the tone and/or context in which the work of the organization is carried out (Dosi & Teece, 1998).
Project competency	"Competence of project managers to manage formalized processes, and to plan, monitor and co-ordinate" (Frame, 1999; Turner, 1999)

Social competence	"The development of social-cognitive skills and knowledge, including the capacity for emotional control, to mediate behavioral performance in specific contexts, which in turn are judged by the self and others to be successful and thereby increase the likelihood of positive psychosocial adjustment."(Yeates, 1989)
Technical competency	Technical competencies are the "hard skills"—the application of knowledge and skills needed to perform effectively in a specific job or group of jobs within the organization. These types of competencies are closely related to the knowledge and skills or "know-how" needed for successful performance.

Appendix 4. Components of the healthcare delivery system in India

Level of care	Type of institution	Description
Tertiary care	**Medical college hospital**	Catchment area undefined. Provides advanced diagnostic and therapeutic facilities. Responsible for medical education.
	District hospital	Catchment area of 3,000,000. Between 101-500 hospital beds. Provides secondary specialized services.
Secondary care	**Sub-district hospital**	Catchment area of 500,000. Between 31-100 hospital beds. First referral unit. Provides specialist services including emergency obstetrics and psychiatric services.
	Community health center (CHC)	Catchment area of 120,000. 30 hospital beds. Referral site for four PHCs. Led by Medical Officer in Charge.
Primary care	**Primary health center (PHC)**	Catchment area of 30,000. Referral site for 6 sub-centers. Provides curative, preventive, and promotive services. Led by Medical Officer.
	Sub-center (SC)	Catchment area of 5,000. First contact point for the community. Led by Auxiliary Nurse Midwife.

Adapted from (McNatt et al., 2016)

Appendix 5. Example of job responsibilities by cadre type

Level	Health worker type	Example Responsibilities	Remarks
Block	Medical Officer (MO)	Curative work: • Organize the dispensary, outpatient department (OPD) and allot duties to the ancillary staff to ensure the smooth running of the OPD. • Cooperate and coordinate with other institutions providing medical care services in his/her area. • Organize and participate in the "Village Health and Nutrition Day" at Anganwadi Centre once in a month. Preventive and Promotive Work: • The Medical Officer will ensure that all the members of his/her Health Team are fully conversant with the various National Health & Family Welfare Programs including NRHM to be implemented in the area allotted to each Health functionary. • Further supervise their work periodically both in the clinics and in the community setting to give them the necessary guidance and direction. • Prepare operational plans and ensure effective implementation of the same to achieve the laid down targets under different National Health and Family Welfare programs. • The MO will assist in the formulation of village health and sanitation plan through the ANMs and coordinate with the PRIs in his/her PHC area. • Conduct field investigations to delineate local health problems for planning changes in the strategy for the effective delivery health services. • Keep close liaison with Block Development Officer and his/her staff, community leaders, and various social welfare agencies in his/her area and involve them to the best advantage in the promotion of health programs in the area. • Wherever possible, the MO will conduct field investigations to delineate local health problems for planning changes in the strategy for the effective delivery of Health and Family welfare services. • Coordinate and facilitate the functioning of the AYUSH doctor in the PHC. • Manage national programs related to Reproductive and Child Health, Universal Immunization Program (UIP), National Vector Borne Disease	• MOs are expected to undertake responsibilities that include curative, promotive, and preventative health services in a block. • It is implied that an MO will solely be responsible for the proper functioning of the PHCs, activities related to Reproductive and Child Health (RCH), National Rural Health Mission (NRHM), and other National Programs. • Source of the job description: (Government of India, 2012a)

		Control Program (NCBDCP) that includes malaria and kala-azar, Control of Communicable Disease including leprosy and tuberculosis. Training: • Organize training programs including continuing education for the staff of PHC and ASHA under the guidance of the district health authorities and Health & Family Welfare Training centers. • Maintain and update a database of staff and the training undergone by them. • Make arrangements/ guidance to the Health Assistant Female and Health Worker Female in organizing training programs for ASHAs. Administrative work: • Supervise the work of staff working under him/her. • Ensure to keep up to date inventory and stock register of all the stores and equipment supplied to him/her and will be responsible for its correct accounting. • Discharge all the financial duties entrusted to him/her. • Hold monthly staff meetings with his/her own staff with a view to evaluating the progress of work and suggesting steps to be taken for further improvements. Other NCD programs • Diagnosis and treatment of common ear diseases. • Diagnosis and treatment of common mental disorders and to provide referral service. Treatment of psychosis, depression, anxiety disorders, and epilepsy could be done at this level after training. • Early detection, treatment as far as possible, and referral of Diabetes Mellitus, Hypertension, CVD, and stroke.	
State	Joint Director (JD)	• Prepare all the program related proposals and get the approval of DG through the Additional Director / Director and implement them. • Conduct implementation, supervision, monitoring and evaluation of the programs related to the department, and inform about the situation to the Additional Director / Director. • Ensure the achievement of the target by ensuring physical and financial review and quality.	• Overall, job descriptions for Joint Directors in the directorates are generic. • There is minimal variation in JDs across divisions. • Sources of the job description: (Government of Uttar Pradesh, 2018)

		• Visit the field at least four areas in a month as per the instructions of the Additional Director/Director. • After allotting the work smoothly among the staff of the section, important tasks such as Right to Information Act, court cases, human rights issues, Legislative Assembly, Legislative Council, Lok Sabha, Rajya Sabha Questions, Assurances, and cases of other legislative bodies can be settled down in a time-bound manner. • Settle down the counter-petition received by the various departmental organizations in a time-bound manner. • Have a meeting once in a month with different organizations on the scheduled date. • Complete other tasks allotted by the Director-General and Director.	
State	Additional Director (AD)	• Ensure quality of supervision, monitoring, and evaluation of all the work related to the relevant. • Travel four times in a month to review the programs. • Responsible for the accomplishment of the related tasks through the Joint Director in his supervision. • Will be the nodal officer for the case and assurance of the questions of the Legislative Assembly/Legislative Council/Lok Sabha/Rajya Sabha/Information Commission, Honorable High Court, and other legal institutions. • Will be the controlling officer of the joint directors who are subordinate to him. • Will do the other allotted work as directed by Director/Director-General.	• Overall, job descriptions for Additional Directors in the directorates are also generic. • There is minimal variation in job responsibilities listed across divisions in the directorate. • Sources of the job description: (Government of Uttar Pradesh, 2018)
State	Director	Not available	The job description of the directors is not defined in the GOUP document.

Appendix 6. Essential Public Health Functions (EPHFs) globally

Essential public health services, CDC (USA, 1994)	Core public health functions, NPHP (Australia, 2000)	Scope of modern public health system, National Health Service (UK, 2001)	Essential public health functions, World Bank (India, 2004)
1. Monitoring, evaluation, and analysis of health status 2. Diagnosing and investigating health problems and health hazards in the community 3. Informing, educating, and empowering people about health issues 4. Mobilizing community partnerships to identify and solve health problems 5. Developing policies and plans that support individual and community health efforts 6. Enforcing laws and regulations that protect health and ensure safety 7. Linking people to needed personal health services and assure the provision of health care when otherwise unavailable 8. Assuring a competent public and personal health care workforce 9. Evaluating effectiveness, accessibility, and quality of personal and population-based health services 10. Searching for new insights and innovative solutions to health problems	1. Health surveillance, monitoring, and analysis 2. Preventing and controlling communicable and noncommunicable diseases and injuries through risk factor reduction, education, screening, immunization, and other interventions 3. Promoting and supporting healthy lifestyles and behaviours among individuals, families, communities, and the wider society 4. Promoting, developing, and supporting healthy public policy, including legislation, regulation, and fiscal measures 5. Planning, funding, managing, and evaluating health gain and capacity building programs designed to achieve measurable improvements in health status and to strengthen skills, competencies, systems, and infrastructure 6. Strengthening communities and building social capital through consultation, participation, and empowerment 7. Promoting, developing, supporting, and initiating actions that ensure safe and healthy environments 8. Promoting, developing, and supporting healthy growth and development throughout all life stages 9. Promoting, developing, and supporting actions to improve the health status of Aboriginal and Torres Strait Islanders	1. Health surveillance, monitoring, and analysis 2. Investigating disease outbreaks, epidemics, and risks to health 3. Establishing, designing, and managing health promotion and disease prevention programs 4. Enabling and empowering communities and citizens to promote health and reduce inequalities 5. Creating and sustaining cross-governmental and intersectoral partnerships to improve health and reduce inequalities 6. Ensuring compliance with regulations and laws to protect and promote health 7. Developing and maintaining a well-educated and trained, multidisciplinary public health workforce 8. Ensuring the effective performance of NHS services to meet goals in improving health, preventing disease, and reducing inequalities 9. Researching, developing, evaluating, and innovating 10. Ensuring the quality of the public health function	1. Health situation monitoring and analysis 2. Epidemiological surveillance/disease prevention and control 3. Health promotion 4. Regulation and enforcement in public health 5. Social participation and empowerment 6. Development of policies and planning in public health and steering role of the Ministry of Health and Family Welfare 7. Evaluation and promotion of equitable access to health services 8. Human resource development and training in public health 9. Quality assurance in personal and population-based health services 10. Research, development, and implementation of innovative public health solutions 11. Management capacity to organize health systems and services in public health 12. Reduction of the impact of emergencies and disasters on health

Obligatory public health functions, Ministry of Health (Indonesia, 2004)	Core functions framework, Ministry of Health (British Columbia, 2005)	Essential public health functions, Sistema Único de Saúde (Brazil, 2006)	Core public health functions, Public Health Clinical Network (New Zealand, 2011)
1. Basic health services 2. Community nutrition 3. Referral and supporting services 4. Communicable disease control 5. Environmental health and sanitation 6. Health promotion 7. Prevention and management of narcotics and substance abuse	Core programmes 1. Health improvement 2. Disease, injury and disability prevention 3. Environmental health 4. Health emergency management Public health strategies 1. Health promotion 2. Health protection 3. Preventive interventions 4. Health assessment and disease surveillance Systems capacity 1. Health information system 2. Quality management capacity Lenses 1. Population lens 2. Inequality lens	1. Monitoring, analysis, and evaluation of health situation in the state 2. Surveillance, investigation and control of risks and harms to health 3. Health promotion 4. Social participation in health 5. Policy development and institutional capacity for planning and public management of health 6. Capacity for regulation, oversight, control and audit in health 7. Promotion and guarantee of universal and equitable access to health services 8. Human resources management, development and formation 9. Promotion and guarantee of quality in health services 10. Research and technology incorporation in health 11. Coordination of the regionalization and decentralization process in health	1. Surveillance and assessment of the population's health and of health hazards in the community 2. Public health capacity development: ensuring the effectiveness and efficiency of the services 3. Health promotion: enabling people to increase control over and improve their health 4. Health protection: protecting communities against public health hazards 5. Preventive interventions: population programmes delivered to individuals

Essential functions of public health, Israeli Association of Public Health Physicians (Israel, 2012)	Essential public health functions in Mozambique and Botswana (CDC Global Health, 2012)	Domains of public health capacity, European Commission (Europe, 2014)	Essential public health services, Government of China (2015)[a]
1. Leadership in public health policy and management 2. Monitoring and evaluation of population health 3. Evaluation of efficiency, effectiveness and quality of health services 4. Environmental health protection 5. Research 6. Health promotion and disease prevention 7. Preparedness for and mitigation of public health emergencies 8. Development and training of public health workforce 9. Partnerships to promote knowledge, coordination and optimal use of resources 10. Public health legislation, control and enforcement	1. Monitoring health status to identify 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. Enforce laws and regulations that protect health and ensure safety 5. Mobilize community partnerships to identify and solve health problems 6. Develop policies and plans that support individual and community health efforts 7. Link people to personal health services 8. Assure a competent health workforce 9. Evaluate and assure effectiveness, accessibility and quality of preventive health services 10. Research for new insights and innovative solutions to health problems 11. Disaster preparedness	1. Leadership and governance 2. Organizational structures 3. Financial resources 4. Workforce 5. Partnerships 6. Knowledge development	1. Establishment of health records for all citizens 2. Health education 3. Children's health management (0–6 years old) 4. Maternal health management 5. Vaccination 6. Reporting and handling of infectious diseases and public health emergencies 7. Health management for elderly people 8. Health management for patients with hypertension 9. Health management for patients with type 2 diabetes 10. Management for patients with severe mental illness 11. Health supervision and management 12. Traditional Chinese medicine management 13. Tuberculosis management

[a]Latest revision (prior lists date from 2011, 2009 and pre-2009).

Source: (World Health Organization, 2018)

Appendix 7. Planned research activities

Activity	Specific aims	Methods	Sample approach	Sample size/Participants	Responsibilities
Activity #1: Cross-sectional district-level survey on core public health competencies	• Assess the level of public health competencies of health cadres • Characterize key aspects of motivation, empowerment, workplace barriers/ enablers	Cross-sectional quantitative survey	• 25 HPDs[****] and 25 non-HPDs • Eligible district level participants include:[††††] CMOs, CMSs, ACMOs, DPMs, Asst DPMs, DAMs, AROs; DHOs; DPHNs	• A maximum of 600 respondents surveyed across 50 districts (a maximum of 300 respondents in 25 HPDs and 300 respondents in 25 non-HPDs) • In each district, a maximum of 12 respondents will be sampled.	Data collection conducted by Oxford Policy Management under the supervision of JHSPH
Activity #2: Cross-sectional block-level survey on public health competencies	• Assess the level of public health competencies of health cadres • Characterize key aspects of motivation, and workplace barriers/enablers	Cross-sectional quantitative survey	• 25 HPDs and 25 non-HPDs • Eligible respondents include[‡‡‡‡] BPMs, BCPMs; MOs, MOICs, HEOs	• A maximum of 650 respondents will be surveyed across a random selection of blocks within a district. For each cadre, 130 respondents will be selected	Data collection conducted by Oxford Policy Management under the supervision of JHSPH

[****] HPD: determined by the Department of Health and Family Welfare for implementation of focused health care intervention under the National Rural Health Mission. These are identified as the bottom 25% of the districts in every state according to the ranking based on a composite health index. This index is created using District Level Household Surveys conducted by the Ministry of Health and Family Welfare. (Ministry of Health and Family Welfare, 2018)

[††††] District level: Chief Medical Officers (CMOs); Chief Medical Superintendent (CMS); Assistant Chief Medical Officers (ACMOs); District Process Managers (DPMs); Assistant District Process Managers (ADPMs); Assistant Research Officers (AROs); District Administrative Managers (DAMs); District Health Officer (DHO), and District Public Health Nursing Officer (DPHNs)

[‡‡‡‡] Block level: Block Program Managers (BPMs); Block Community Process Managers (BCPMs); Medical Officers (MOs); Medical Officers-In-Charge (MOICs); Health Extension Officers (HEOs).

Appendix 8. Comparison of the domains of core public health competency frameworks globally

Country →	**Canada (Public Health Agency of Canada, 2008)**	**Europe (Foldspang et al., 2018)**	**New Zealand (Public Health Association of New Zealand, 2007)**	**Americas (Pan American Health Organization, 2013)**	**Spain (Benavides et al., 2006)**	**United Kingdom (Public Health England et al., 2019)**	**United States of America (The Council on Linkages, 2014)**
Developed by →	Public health agency of Canada, Government of Canada	Association of Schools of Public Health in the European Region (ASPHER)	Public Health Association of New Zealand	Pan American Health Organization	Spanish Association of Public Health and Healthcare (SESPAS) and Spanish Society of Epidemiology (SEE)	Public Health England, UK Government	Council of linkages between academia and public health practice
Domain #1	Public health sciences	Methods in public health – quantitative and qualitative methods	Health systems	Health situation analysis	Analyze the health situation of the community	Measure, monitor and report population health and wellbeing; health needs; risks; inequalities; and use of services	Analytical/Assessment Skills
Domain #2	Assessment and analysis	Population health and its social and economic determinants	Public Health Science	Surveillance and control of risks and threats	Describe and analyze the association and impact of risk factors and health problems and the impact of health services	Promote population and community health and wellbeing, addressing the wider determinants of health and health inequalities	Policy Development/Program Planning Skills

Domain #3	Policy and program planning, implementation and evaluation	Population health and its material – physical, radiological, chemical and biological – environmental determinants	Policy, Legislation, and Regulation	Health promotion and social participation	Control diseases and emergency situations	Protect the public from environmental hazards, communicable disease, and other health risks, while addressing inequalities in risk exposure and outcomes	Communication Skills
Domain #4	Partnerships, collaboration, and advocacy	Heath policy; economics; organizational theory, leadership, and management	Research and Evaluation	Policy, planning, regulation and control	Contribute to defining health system management	Work to, and for, the evidence base, conduct research, and provide informed advice	Cultural Competency Skills
Domain #5	Diversity and inclusiveness	Health promotion, health protection, and disease prevention	Community Health Development	Equitable access and quality of individual and public health services	Promote the defense of health in intersectoral policies	Audit, evaluate and re-design services and interventions to improve health outcomes and reduce health inequalities	Community Dimensions of Practice Skills
Domain #6	Communication	Ethics	Te Tiriti o Waitangi	International /global health	Contribute to design and implement health programs and interventions	Work with, and through, policies and strategies to improve health outcomes and reduce health inequalities	Public Health Sciences Skills
Domain #7	Leadership		Working Across and Understanding Cultures		Encourage social participation and strengthen the degree of control of citizens over their own health	Work collaboratively across agencies and boundaries to improve health outcomes and reduce health inequalities	Financial Planning and Management Skills

Domain #8			Communication		Manage services and programs	Work in a commissioning-based culture to improve health outcomes and reduce health inequalities	Leadership and Systems Thinking Skills
Domain #9			Leadership, Teamwork, and Professional Liaison		Evaluate services and programs	Work within political and democratic systems and with a range of organizational cultures to improve health outcomes and reduce health inequalities	
Domain #10			Advocacy		Perform sanitary inspections and audits	Provide leadership to drive improvement in health outcomes and the reduction of health inequalities	
Domain #11			Professional Development and Self-Management		Develop guides and protocols	Communicate with others to improve health outcomes and reduce health inequalities	
Domain #12			Planning and Administration			Design and manage programs and projects to improve health and reduce health inequalities	
Domain #13						Prioritize and manage resources at a population/ systems level to achieve equitable health outcomes and return on investment	

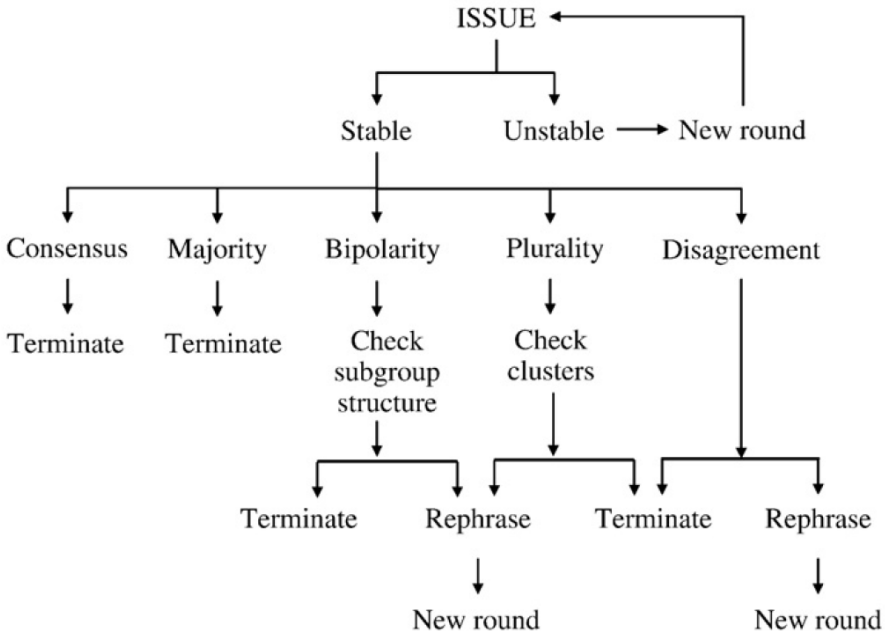
Appendix 9. Initial list of 40 competency statements across eight domains

Domains and Competency Statements
Domain 1: Public Health Sciences
1. Demonstrate knowledge about the following concepts: the health status of populations, inequities in health, the determinants of health and illness, strategies for health promotion, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.
2. Demonstrate knowledge about the history, structure and interaction of public health and health care services at local, district, state, national, and international levels.
3. Apply the public health sciences (e.g., behavioral and social sciences, biostatistics, epidemiology, environmental public health, demography) to practice.
4. Use evidence and research to inform health policies and programs.
Domain 2: Assessment and Analysis
5. Identify relevant and appropriate sources of information, including community resources.
6. Collect, store, retrieve and use accurate and appropriate data on public health issues.
7. Analyze information to determine appropriate implications, uses, gaps and limitations.
8. Determine the meaning of information, considering the current ethical, political, scientific, socio-cultural and economic contexts.
9. Recommend specific actions based on the analysis of information.
Domain 3: Policy and Program Management
10. Describe selected policy and program options to address a specific public health issue.
11. Describe the implications of each option, especially as they apply to the determinants of health and recommend or decide on a course of action.
12. Develop a plan to implement a course of action taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).
13. Take appropriate action to address a specific public health issue.

Domains and Competency Statements
14. Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses, etc.)
15. Evaluate an action, policy or program.
16. Demonstrate the ability to fulfill functional roles in response to a public health emergency.
17. Establishes teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining scope of work and timeline).
18. Motivates personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).
19. Uses evaluation results to improve program and organizational performance.
Domain 4: Financial Management and Budgeting
20. Justifies programs for inclusion in budgets, develops and defends budgets.
21. Prepares proposals for funding (e.g., foundations, government agencies, corporations).
22. Uses financial analysis methods in making decisions about policies, programs, and services (e.g., economic analyses).
23. Manages programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).
Domain 5: Partnerships and Collaboration
24. Identify and collaborate with partners in addressing public health issues.
25. Use skills such as team building, negotiation, conflict management and group facilitation to build partnerships.
26. Mediate between differing interests in the pursuit of health and well-being and facilitate the allocation of resources.
Domain 6: Social and Cultural Determinants
27. Recognize how the determinants of health (biological, social, cultural, economic and physical) influence the health and well-being of specific population groups.
28. Address population diversity when planning, implementing, adapting and evaluating public health programs and policies.

Domains and Competency Statements
29. Apply culturally relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status, sexual orientations and abilities.
Domain 7: Communication
30. Communicate effectively with individuals, families, groups, communities and colleagues.
31. Interpret information for professional, nonprofessional and community audiences.
32. Mobilize individuals and communities by using appropriate media, community resources and social marketing techniques.
33. Use current technology to communicate effectively.
34. Advocate for healthy public policies and services that promote and protect the health and well-being of individuals and communities.
Domain 8: Leadership
35. Describe the mission and priorities of the public health organization where one works, and apply them in practice.
36. Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.
37. Utilize public health ethics to manage self, others, information and resources.
38. Contribute to team and organizational learning in order to advance public health goals.
39. Contribute to maintaining organizational performance standards.
40. Demonstrate an ability to build community capacity by sharing knowledge, tools, expertise and experience.

Appendix 10. Hierarchical stopping criteria for Delphi studies



From (Dajani et al., 1979; von der Gracht, 2012)

Appendix 11. Consolidation of 48 competency statements to develop draft survey tool (37 items)

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Public Health Sciences	1	Demonstrate knowledge about the following concepts: the health status of populations, inequities in health, the determinants of health and illness, strategies for health promotion, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.	1	Describe key concepts in public health (e.g., the health status of populations, the determinants of health and illness, strategies for health promotion, relationship between health and poverty, inequities in health and various forms of disadvantages, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.)		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Public Health Sciences	2	Apply the public health sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice including relationships between health and poverty and other forms of disadvantage.	2	Apply the public health tools, techniques, and sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice.	Delphi #2 is similar to Delphi #4 and Delphi #5.	Delphi #4 is subsumed in Delphi #2. Delphi #5 is merged with Delphi #2. Result is Survey #2.
Public Health Sciences	3	Use evidence and research to inform health policies and programs.	3	Use data, evidence, and research to inform health policies, programs, and organizational performance.	Delphi #3 similar to Delphi #9.	Delphi #9 is subsumed in Delphi #3. Result is Survey #3.
Public Health Sciences	4	Demonstrate fundamental action to undertake community need assessment.			Delphi #4 similar to Delphi #2 as both relate to public health practice.	Delphi #4 is subsumed in Delphi #2. Result is Survey #2.
Public Health Sciences	5	Apply knowledge of public health tools and technique.			Delphi #5 similar to Delphi #2.	Delphi #5 is merged with Delphi #2 to include public

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
						health tools and techniques. Result is Survey #2.
Assessment and Analysis	6	Identify relevant and appropriate sources of information, including community resources.	4	Identify relevant and appropriate sources of information, including community resources.		
Assessment and Analysis	7	Collect, store, retrieve, and use accurate and appropriate data on public health issues.	5	Collect, store, retrieve and use accurate and appropriate data on public health issues.		
Assessment and Analysis	8	Analyze information to determine appropriate implications, uses, gaps, and limitations.	6	Analyze information to determine appropriate implications, uses, gaps, and limitations.		
Assessment and Analysis	9	Recommend specific actions based on the analysis of information.			Delphi #9 similar to Delphi #3 and Delphi #20.	Delphi #9 is subsumed in Delphi #3. Result is Survey #3.
Assessment and Analysis	10	Assess the accuracy and importance of data for public health decision making.	7	Assess the accuracy and importance of data for public health decision making.		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Policy and Program Management	11	Describe selected policy and program options to address a specific public health issue.	8	Describe selected policy and program options to address a specific public health issue.		
Policy and Program Management	12	Describe the implications of each option, especially as they apply to the determinants of health, and recommend or decide on a course of action.	9	Describe the implications of each policy and program option, especially as they apply to the determinants of health and recommend or decide on a course of action.		
Policy and Program Management	13	Develop a plan to implement a course of action, taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).	10	Develop a plan to implement a course of action taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).		
Policy and Program Management	14	Take appropriate action to address a specific public health issue.			Delphi #14 similar to Delphi #15	Delphi #14 is included in Delphi #15. Final result is Survey #11.

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Policy and Program Management	15	Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses, etc.), including the allocation of personnel, financial, and other resources.	11	Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses) to address a specific public health issue.		
Policy and Program Management	16	Monitor and evaluate an action, policy, or program.	12	Monitor and evaluate an action, policy, or program.		
Policy and Program Management	17	Demonstrate the ability to fulfill functional roles in response to a public health emergency.	13	Demonstrate the ability to fulfill functional roles in response to a public health emergency.		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Policy and Program Management	18	Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining the scope of work and timeline).	14	Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining scope of work and timeline).		
Policy and Program Management	19	Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).	15	Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).		
Policy and Program Management	20	Use evaluation and data to improve health systems, programs, and organizational performance.			Delphi #20 similar to Delphi #16 and Delphi #3.	Delphi #20 is consolidated with Delphi #3 (organizational performance part). Result of consolidation is Survey #3. Rest of

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
						Delphi #20 is almost identical to Delphi #16.
Policy and Program Management	21	Support learning within an organization including on-the-job learning.	16	Support learning within an organization including on the job training to advance public health goals.		
Policy and Program Management	22	Leverage technology to innovate, understand, apply, and evaluate/improvise.			Delphi #22 similar to Delphi #39 (could be consolidated)	Delphi #39 is similar to Delphi #36. Delphi #22, 36, and 39 combined. Outcome is Survey #28.
Policy and Program Management	23	Be able to manage time appropriately.	17	Manage time appropriately.		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Financial Management and Budgeting	24	Justify programs for inclusion in budgets, develop and defend budgets.	18	Justify programs for inclusion in budgets, develop and defend budgets.		
Financial Management and Budgeting	25	Prepare proposals for funding (e.g., to foundations, government agencies, corporations).	19	Prepare proposals for funding (e.g., foundations, government agencies, corporations).		
Financial Management and Budgeting	26	Use financial analysis methods in making decisions about policies, programs, and services (e.g., economic analyses).	20	Make use of financial analysis and accounting techniques in making decisions about policies, programs, and services.	Delphi #26 similar to Delphi #28.	Delphi #28 conslidated with Delphi #26. Outcome is Survey #20.
Financial Management and Budgeting	27	Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).	21	Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).		
Financial Management and Budgeting	28	Use financial and accounting techniques for budgeting, procurement,			Delphi #28 similar to Delphi #26.	Delphi #28 conslidated with Delphi #26.

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
		staffing, accounting, and expenditure tracking.				Outcome is Survey #20.
Partnerships and Collaboration	29	Identify and collaborate with partners in addressing public health issues.	22	Identify and collaborate with partners in addressing public health issues.		
Partnerships and Collaboration	30	Use skills such as team building, negotiation, conflict management, and group facilitation to build partnerships.	23	Use skills such as team building, negotiation, conflict management, group facilitation, and mediation between differing interests to build partnerships.	Delphi #30 similar to Delphi #31 ("mediation" of Delphi #31 can come under Delphi #30)	Delphi #31 is combined with Delphi #30. Outcome is Survey #23.
Partnerships and Collaboration	31	Mediate between differing interests in the pursuit of health and well-being.			Delphi #31 similar to Delphi #30.	Delphi #31 is combined with Delphi #30. Outcome is Survey #23.

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Partnerships and Collaboration	32	Be able to listen, engage, and mobilize communities.	24	Mobilize communities by using appropriate media, community resources, and social marketing techniques.	Delphi #32 similar to Delphi #38.	Delphi #38 is included in Delphi #32. Result is Survey #24.
Social and Cultural Determinants	33	Recognize how the determinants of health (biological, social, cultural, economic, and physical) influence the health and well-being of specific population groups.	25	Recognize how the determinants of health (biological, social, cultural, economic and physical) influence the health and well-being of specific population groups.		
Social and Cultural Determinants	34	Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.	26	Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.		
Social and Cultural Determinants	35	Apply culturally relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health	27	Apply culturally relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status,		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
		status, sexual orientations, and abilities.		sexual orientations and abilities.		
Communication	36	Listen and communicate effectively with individuals, families, groups, communities, and colleagues, including supervisors and team members.	28	Listen, engage, and communicate effectively (e.g., by leveraging technology) with individuals, families, groups, communities, and colleagues including supervisors and team members.	Delphi #36 similar to Delphi #39	Delphi #39 is included in Delphi #36. Result is Survey #28.
Communication	37	Interpret information for professional, nonprofessional, and community audiences.	29	Interpret information for professional, nonprofessional and community audiences.		
Communication	38	Mobilize individuals and communities by using appropriate media, community resources, and			Delphi #38 similar to Delphi #32	Delphi #38 is included in Delphi #32. Result is Survey #24.

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
		social marketing techniques.				
Communication	39	Use current technology to communicate effectively.			Delphi #39 similar to Delphi #36	Delphi #39 is included in Delphi #36. Result is Survey #28.
Communication	40	Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.	30	Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.		
Leadership	41	Describe the mission and priorities of the public health organization where one works and apply them in practice.	31	Describe the mission and priorities of the public health organization where one works and apply them in practice.		
Leadership	42	Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.	32	Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.		

Domains	Delphi #	Final Delphi workshop competency statements	Survey #	Items in the competency assessment survey	Notes on similarities between competency statements	Notes on the consolidation/final list
Leadership	43	Utilize public health ethics to manage self, others, information, and resources.	33	Utilize public health ethics to manage self, others, information, and resources.		
Leadership	44	Contribute to team and organizational learning in order to advance public health goals.			Delphi #44 similar to Delphi #21.	Delphi #44 is consolidated with Delphi #21. Result is Survey #16.
Leadership	45	Contribute to maintaining organizational performance standards.	34	Contribute to maintaining organizational performance standards.		
Leadership	46	Demonstrate an ability to build community capacity by sharing knowledge, tools, expertise, and experience.	35	Build community capacity by sharing knowledge, tools, expertise, and experience.		
Leadership	47	Identify a need for change, manage change and processes.	36	Identify a need for change, manage change and processes.		
Leadership	48	Maintain organizational justice, equality, and fairness in dealing with subordinates.	37	Maintain organizational justice, equality, and fairness in dealing with subordinates.		

Appendix 12. Initial 37-item tool

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and the main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
1	Describe key concepts in public health (e.g., the health status of populations, the determinants of health and illness, strategies for health promotion, relationship between health and poverty, inequities in health and various forms of disadvantages, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.)
2	Apply the public health tools, techniques, and sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice (e.g., community needs assessment).
3	Use data, evidence, and research to inform health policies, programs, and organizational performance.
4	Identify relevant and appropriate sources of information, including community resources.
5	Collect, store, retrieve and use accurate and appropriate data on public health issues.
6	Analyze information to determine appropriate implications, uses, gaps, and limitations.
7	Assess the accuracy and importance of data for public health decision making.
8	Describe selected policy and program options to address a specific public health issue.
9	Describe the implications of each policy and program option, especially as they apply to the determinants of health and recommend or decide on a course of action.
10	Develop a plan to implement a course of action taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and the main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
11	Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses) to address a specific public health issue.
12	Monitor and evaluate an action, policy, or program.
13	Demonstrate the ability to fulfill functional roles in response to a public health emergency.
14	Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining scope of work and timeline).
15	Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).
16	Support learning within an organization including on the job training to advance public health goals.
17	Manage time appropriately.
18	Justify programs for inclusion in budgets, develop and defend budgets.
19	Prepare proposals for funding (e.g., foundations, government agencies, corporations).
20	Make use of financial analysis and accounting techniques in making decisions about policies, programs, and services.
21	Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).
22	Identify and collaborate with partners in addressing public health issues.
23	Use skills such as team building, negotiation, conflict management, group facilitation, and mediation between differing interests to build partnerships.

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and the main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
24	Mobilize communities by using appropriate media, community resources, and social marketing techniques.
25	Recognize how the determinants of health (biological, social, cultural, economic and physical) influence the health and well-being of specific population groups.
26	Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.
27	Apply culturally-relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status, sexual orientations and abilities.
28	Listen, engage, and communicate effectively (e.g., by leveraging technology) with individuals, families, groups, communities, and colleagues including supervisors and team members.
29	Interpret information for professional, nonprofessional and community audiences.
30	Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.
31	Describe the mission and priorities of the public health organization where one works, and apply them in practice.
32	Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.
33	Utilize public health ethics to manage self, others, information, and resources.
34	Contribute to maintaining organizational performance standards.
35	Build community capacity by sharing knowledge, tools, expertise, and experience.
36	Identify a need for change, manage change and processes.
37	Maintain organizational justice, equality, and fairness in dealing with subordinates.

Appendix 13. Number and percentage of missing values for each item

Item number*	Missing	Total	Percent Missing
CA1	4	166	2.41
CA2	4	166	2.41
CA3	5	166	3.01
CA4	8	166	4.82
CA5	6	166	3.61
CA6	5	166	3.01
CA7	5	166	3.01
CA8	3	166	1.81
CA9	4	166	2.41
CA10	4	166	2.41
CA11	4	166	2.41
CA12	4	166	2.41
CA13	8	166	4.82
CA14	4	166	2.41
CA15	2	166	1.2

Item number	Missing	Total	Percent Missing
CA23	4	166	2.41
CA24	4	166	2.41
CA25	4	166	2.41
CA26	6	166	3.61
CA27	7	166	4.22
CA28	5	166	3.01
CA29	8	166	4.82
CA30	4	166	2.41
CA31	5	166	3.01
CA32	4	166	2.41
CA33	3	166	1.81
CA34	8	166	4.82
CA35	3	166	1.81
CA36	4	166	2.41
CA37	3	166	1.81

*Item corresponds to the item number in Appendix 12.

Appendix 14. Patterns of missing values

_pattern	_mv	_freq
++++++++++++++++++++++++++++++++++	0	125
++++++++++++++++++.++++++++++++++++	1	3
++++++++++++++++.++++++++++++++++++	1	2
++++++++++++.++++++++++++++++++++++	1	2
+++.++++++++++++++++++++++++++++++	1	2
++++++++++++++++++++++++++++++++.+++	1	1
++++++++++++++++++++++++++++++.++++	1	1
++++++++++++++++++++++++++++.++++++++	1	1
++++++++++++++++++++++++.++++++++++	1	1
++++++++++++.++++++++++++++++++++++	1	1
++++++++++.++++++++++++++++++++++++	1	1
+++++++++.++++++++++++++++++++++++	1	1
++++++++.++++++++++++++++++++++++	1	1
++++++.++++++++++++++++++++++++++	1	1
++.++++++++++++++++++++++++++++++	1	1
++++++++++++++++++++.++++++++++.+++	2	1
++++++++++++++++++++.++++++++.+++++++	2	1
++++++++++++.++++++++++++++++++++.+	2	1
++++++++++++.++++++++++++.++++++++++	2	1
++++++++++++.++++++.++++++++++++++++	2	1
++++.++++++++++++++++++++++++++.+++	2	1
++++.++++++++++++++.++++++++++++++++	2	1
+++.++++++++++++++++++++++++.++++++++	2	1
+++.+.++++++++++++++++++++++++++++++	2	1
++.++++++++++++++++++.++++++++++++++	2	1
++++++++.++++++++++++++++++++++.++.++	3	1
++++.++++.++.++++++++++++++.++++++++++	4	1
+++.++.++++++++++++++.++++++.++++++++	4	1
..++++++++++++++++++++++++++++++.+.+.+	5	1
++++++++++++++++++...++.++.+++++++++.	6	1
+++++.+++++++.+++++.++.+++++.++++.+++	6	1
++++++++++++++++++++++++..+.++.++....	8	1
++++++++++..+++++.+.++..+....+.++.+++	12	1
........++++++++++++++++.......++++++	15	1
................+++++.............++++	28	1
....	37	1

Appendix 15. Correlation matrix

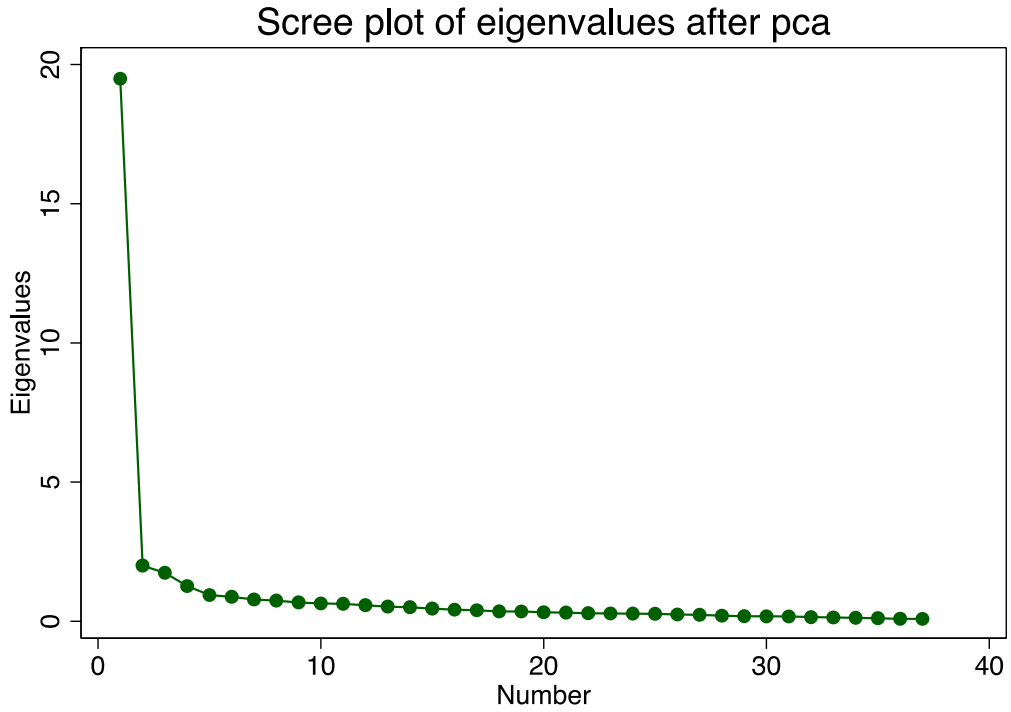
Items	CA1	CA2	CA3	CA4	CA5	CA6	CA7	CA8	CA9	CA10	CA11	CA12	CA13	CA14	CA15	CA16	CA17	CA18	CA19
CA1	1.00																		
CA2	0.63	1.00																	
CA3	0.61	0.66	1.00																
CA4	0.56	0.54	0.58	1.00															
CA5	0.56	0.52	0.66	0.70	1.00														
CA6	0.57	0.44	0.57	0.55	0.73	1.00													
CA7	0.54	0.54	0.63	0.54	0.71	0.76	1.00												
CA8	0.52	0.55	0.74	0.63	0.68	0.61	0.66	1.00											
CA9	0.60	0.48	0.54	0.58	0.60	0.58	0.57	0.56	1.00										
CA10	0.57	0.50	0.58	0.60	0.65	0.58	0.57	0.56	0.70	1.00									
CA11	0.54	0.49	0.56	0.47	0.49	0.52	0.48	0.54	0.62	0.62	1.00								
CA12	0.45	0.38	0.52	0.50	0.53	0.55	0.50	0.57	0.56	0.58	0.73	1.00							
CA13	0.44	0.41	0.50	0.53	0.52	0.49	0.50	0.60	0.48	0.53	0.64	0.72	1.00						
CA14	0.44	0.50	0.51	0.58	0.53	0.50	0.50	0.55	0.54	0.59	0.69	0.61	0.73	1.00					
CA15	0.47	0.31	0.45	0.45	0.59	0.55	0.51	0.51	0.57	0.63	0.65	0.61	0.59	0.63	1.00				
CA16	0.46	0.41	0.54	0.52	0.57	0.60	0.53	0.52	0.60	0.65	0.57	0.62	0.54	0.62	0.68	1.00			
CA17	0.38	0.31	0.42	0.37	0.47	0.45	0.43	0.46	0.49	0.52	0.54	0.55	0.57	0.49	0.63	0.68	1.00		
CA18	0.40	0.50	0.52	0.46	0.48	0.44	0.56	0.55	0.47	0.59	0.50	0.43	0.49	0.54	0.50	0.61	0.55	1.00	
CA19	0.42	0.45	0.49	0.49	0.52	0.48	0.55	0.56	0.42	0.59	0.54	0.43	0.47	0.55	0.50	0.57	0.45	0.79	1.00
CA20	0.29	0.38	0.38	0.30	0.42	0.32	0.42	0.46	0.39	0.51	0.48	0.38	0.36	0.47	0.49	0.46	0.43	0.69	0.71
CA21	0.30	0.44	0.42	0.38	0.45	0.41	0.41	0.38	0.41	0.56	0.47	0.34	0.40	0.50	0.47	0.52	0.41	0.63	0.66
CA22	0.48	0.45	0.43	0.55	0.50	0.55	0.53	0.50	0.53	0.51	0.61	0.52	0.61	0.66	0.48	0.57	0.42	0.54	0.55
CA23	0.46	0.43	0.54	0.62	0.60	0.53	0.50	0.59	0.58	0.54	0.58	0.53	0.62	0.71	0.54	0.60	0.52	0.52	0.53
CA24	0.43	0.50	0.50	0.62	0.55	0.48	0.52	0.46	0.56	0.53	0.55	0.40	0.54	0.64	0.41	0.55	0.36	0.55	0.54
CA25	0.41	0.55	0.50	0.56	0.57	0.53	0.53	0.54	0.61	0.54	0.64	0.59	0.51	0.57	0.51	0.54	0.43	0.47	0.46
CA26	0.45	0.54	0.58	0.57	0.49	0.51	0.49	0.57	0.51	0.51	0.59	0.55	0.62	0.71	0.47	0.47	0.30	0.49	0.45
CA27	0.40	0.47	0.49	0.51	0.51	0.50	0.51	0.58	0.55	0.46	0.57	0.49	0.49	0.61	0.49	0.54	0.35	0.52	0.54
CA28	0.42	0.43	0.43	0.58	0.55	0.50	0.58	0.57	0.51	0.53	0.53	0.52	0.61	0.62	0.50	0.55	0.42	0.47	0.44

CA29	0.46	0.45	0.44	0.56	0.55	0.57	0.54	0.55	0.63	0.58	0.60	0.57	0.58	0.63	0.52	0.59	0.48	0.55	0.50
CA30	0.49	0.52	0.51	0.54	0.50	0.46	0.49	0.50	0.55	0.58	0.55	0.45	0.44	0.61	0.49	0.49	0.39	0.50	0.44
CA31	0.45	0.59	0.49	0.49	0.58	0.57	0.59	0.60	0.46	0.52	0.58	0.55	0.60	0.68	0.49	0.57	0.47	0.59	0.58
CA32	0.38	0.49	0.52	0.65	0.58	0.51	0.58	0.57	0.45	0.55	0.59	0.55	0.57	0.65	0.48	0.58	0.41	0.51	0.55
CA33	0.56	0.57	0.56	0.71	0.62	0.51	0.62	0.68	0.59	0.58	0.50	0.49	0.57	0.66	0.48	0.50	0.39	0.51	0.58
CA34	0.42	0.43	0.49	0.54	0.57	0.51	0.54	0.59	0.50	0.53	0.53	0.56	0.62	0.68	0.55	0.51	0.42	0.50	0.53
CA35	0.42	0.48	0.50	0.62	0.52	0.43	0.51	0.56	0.53	0.58	0.54	0.49	0.56	0.60	0.49	0.57	0.34	0.52	0.56
CA36	0.39	0.45	0.53	0.56	0.56	0.55	0.60	0.60	0.61	0.56	0.56	0.62	0.57	0.65	0.58	0.61	0.45	0.47	0.49
CA37	0.38	0.38	0.37	0.57	0.55	0.46	0.48	0.47	0.44	0.50	0.49	0.55	0.58	0.64	0.51	0.59	0.39	0.47	0.42
Items	**CA20**	**CA21**	**CA22**	**CA23**	**CA24**	**CA25**	**CA26**	**CA27**	**CA28**	**CA29**	**CA30**	**CA31**	**CA32**	**CA33**	**CA34**	**CA35**	**CA36**	**CA37**	
CA20	1.00																		
CA21	0.70	1.00																	
CA22	0.49	0.51	1.00																
CA23	0.46	0.51	0.73	1.00															
CA24	0.46	0.60	0.70	0.72	1.00														
CA25	0.46	0.42	0.60	0.61	0.63	1.00													
CA26	0.36	0.36	0.68	0.69	0.57	0.65	1.00												
CA27	0.54	0.55	0.66	0.65	0.64	0.65	0.64	1.00											
CA28	0.31	0.32	0.71	0.67	0.69	0.61	0.62	0.62	1.00										
CA29	0.45	0.45	0.70	0.73	0.69	0.67	0.58	0.61	0.73	1.00									
CA30	0.51	0.50	0.57	0.63	0.57	0.64	0.55	0.62	0.57	0.69	1.00								
CA31	0.48	0.55	0.59	0.61	0.59	0.58	0.49	0.59	0.58	0.66	0.70	1.00							
CA32	0.43	0.50	0.68	0.65	0.65	0.55	0.64	0.57	0.73	0.68	0.53	0.61	1.00						
CA33	0.40	0.50	0.62	0.65	0.63	0.52	0.56	0.55	0.65	0.64	0.59	0.60	0.60	1.00					
CA34	0.43	0.52	0.58	0.60	0.62	0.47	0.49	0.60	0.61	0.60	0.49	0.69	0.60	0.70	1.00				
CA35	0.45	0.52	0.68	0.7	0.72	0.54	0.62	0.62	0.71	0.65	0.59	0.58	0.76	0.66	0.65	1			
CA36	0.43	0.44	0.57	0.57	0.57	0.64	0.54	0.59	0.65	0.69	0.58	0.58	0.64	0.7	0.66	0.67	1		
CA37	0.25	0.33	0.6	0.62	0.59	0.59	0.57	0.53	0.78	0.62	0.46	0.54	0.65	0.561	0.58	0.59	0.59	1	

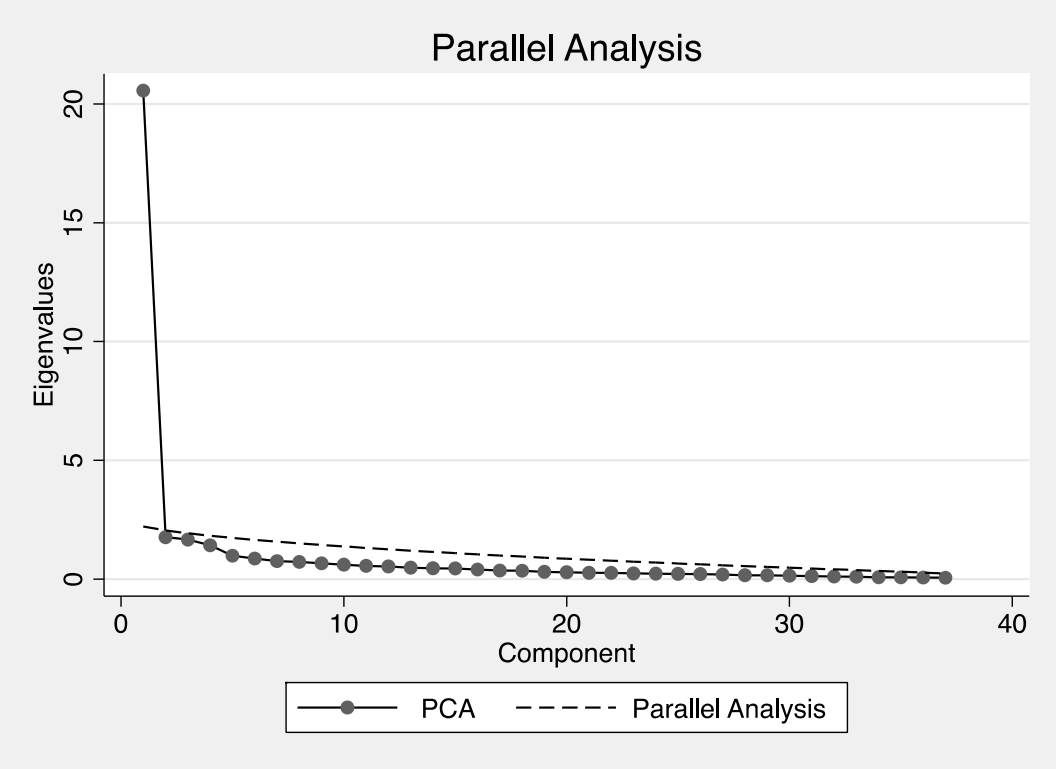
Appendix 16. Principal Components Analysis

Component	Eigenvalue	Proportion	Cumulative
Comp1	19.490	0.527	0.527
Comp2	2.000	0.054	0.581
Comp3	1.741	0.047	0.628
Comp4	1.265	0.034	0.662
Comp5	0.940	0.025	0.688
Comp6	0.879	0.024	0.711
Comp7	0.782	0.021	0.732
Comp8	0.742	0.020	0.753
Comp9	0.678	0.018	0.771
Comp10	0.639	0.017	0.788
Comp11	0.629	0.017	0.805
Comp12	0.578	0.016	0.821
Comp13	0.527	0.014	0.835
Comp14	0.505	0.014	0.849
Comp15	0.454	0.012	0.861
Comp16	0.415	0.011	0.872
Comp17	0.394	0.011	0.883
Comp18	0.354	0.010	0.892
Comp19	0.352	0.010	0.902
Comp20	0.322	0.009	0.911
Comp21	0.311	0.008	0.919
Comp22	0.289	0.008	0.927
Comp23	0.280	0.008	0.934
Comp24	0.273	0.007	0.942
Comp25	0.267	0.007	0.949
Comp26	0.241	0.007	0.955
Comp27	0.230	0.006	0.962
Comp28	0.199	0.005	0.967
Comp29	0.182	0.005	0.972
Comp30	0.176	0.005	0.977
Comp31	0.171	0.005	0.981
Comp32	0.148	0.004	0.985
Comp33	0.136	0.004	0.989
Comp34	0.125	0.003	0.992
Comp35	0.110	0.003	0.995
Comp36	0.090	0.002	0.998
Comp37	0.083	0.002	1.000

Appendix 17. Scree plot indicating one possible factor (n=166)



Appendix 18. Parallel analysis graph



Note: Figure illustrates the expected eigenvalues (the solid line) and parallel analysis (the dotted line), PCA = Principal Components Analysis

Appendix 19. Parallel analysis table

Component	PCA	PA	Difference
1	19.490	2.065	17.425
2	2.000	1.920	0.080
3	1.741	1.819	-0.078
4	1.265	1.732	-0.467
5	0.940	1.654	-0.713
6	0.879	1.584	-0.705
7	0.782	1.517	-0.734
8	0.742	1.454	-0.712
9	0.678	1.394	-0.716
10	0.639	1.340	-0.701
11	0.629	1.287	-0.658
12	0.578	1.236	-0.658
13	0.527	1.187	-0.660
14	0.505	1.141	-0.636
15	0.454	1.095	-0.641
16	0.415	1.051	-0.636
17	0.394	1.007	-0.613
18	0.354	0.967	-0.613
19	0.352	0.926	-0.574
20	0.322	0.887	-0.564
21	0.311	0.849	-0.538
22	0.289	0.812	-0.523
23	0.280	0.776	-0.496
24	0.273	0.740	-0.467
25	0.267	0.704	-0.438
26	0.241	0.670	-0.429
27	0.230	0.636	-0.406
28	0.199	0.603	-0.404
29	0.182	0.570	-0.388
30	0.176	0.538	-0.362
31	0.171	0.506	-0.335
32	0.148	0.474	-0.325
33	0.136	0.442	-0.305
34	0.125	0.408	-0.283
35	0.110	0.375	-0.265
36	0.090	0.338	-0.248
37	0.083	0.296	-0.212

Appendix 20. Objective measurement tool for core public health competencies

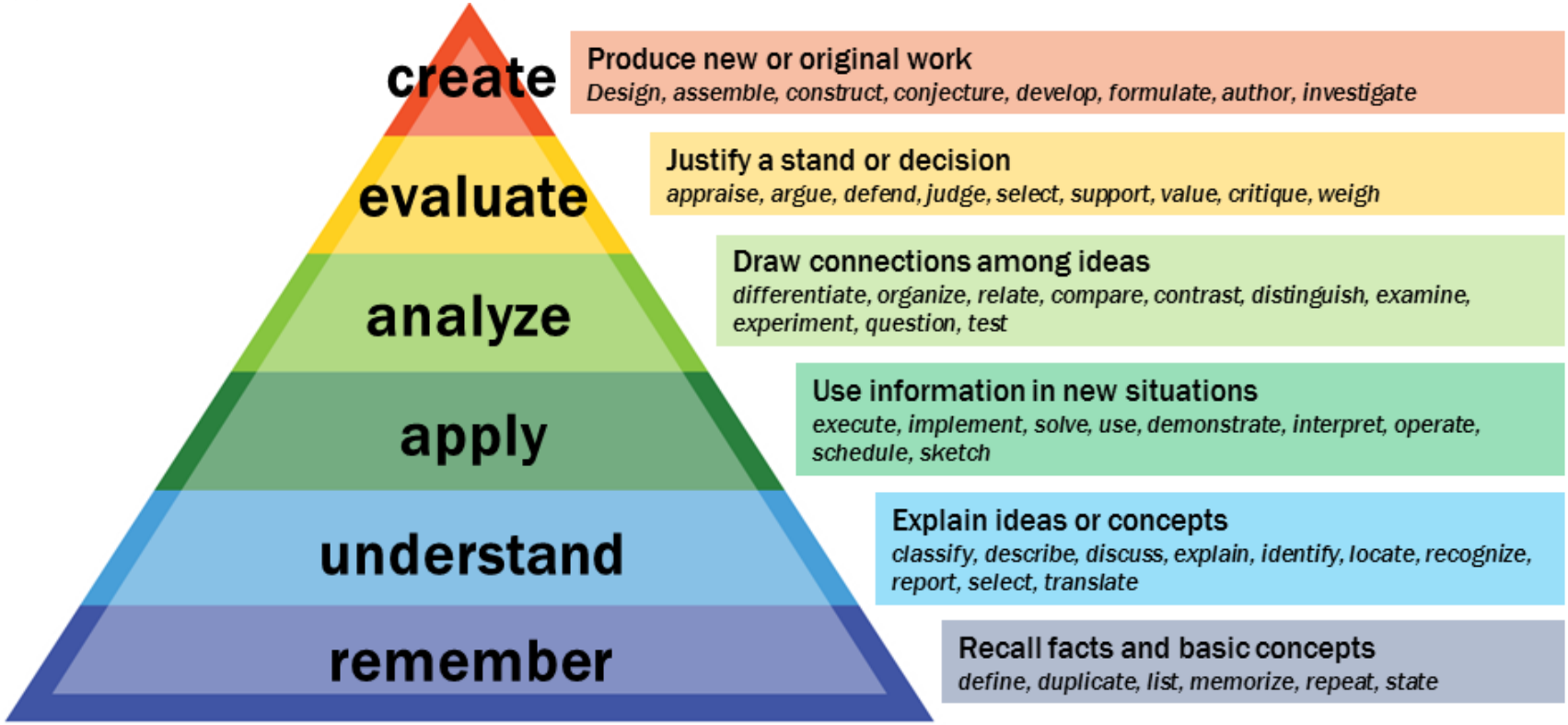
Please check the response option that you think is the correct answer to the question. Please select one response only.	
Item #	Objectively measured competencies
OA.01	**In a community with 20,000 births in a given year, five births are premature. Which of the following values represents this in a manner that allows comparison with other populations?**
a.	0.025
b.	2.50%
c.	25 per 10,000
d.	25 per 100,000*
	Total
OA.02	**When a public health issue emerges for which there is no "evidence base" to suggest a response strategy, which of the following actions on the part of a public health professional is most appropriate?**
a.	Defer action on the issue until further information about the appropriate intervention is available.
b.	Dismiss the issue because there is insufficient evidence to make an informed decision.
c.	Implement several different strategies at once to assess which is most effective.
d.	Start efforts in data collection and community-based research to build a more thorough understanding of the issue.*
	Total
OA.03	**Public health surveillance can be described primarily as which of the following:**
a.	A method to monitor occurrences of public health problems.*
b.	A program to control disease outbreaks.
c.	A system for collecting health-related information.
d.	A system for monitoring persons who have been exposed to a communicable disease.
	Total
OA.04	**A Primary Health Care center establishes a program with community outreach and clinical components that is intended to reduce the number of drug-resistant tuberculosis cases. The best measure to track the program's outcomes is the number of:**
a.	clinical visits for drug-resistant tuberculosis
b.	community education sessions
c.	drug-resistant tuberculosis cases*
d.	patients receiving follow-up care for drug-resistant tuberculosis
	Total
OA.05	**The management of a health care facility requires staff to adhere to ethical principles and provide culturally appropriate care. The inclusion of these values is most likely to influence which of the following aspects of health care provided by this facility?**
a.	Acceptability*

Please check the response option that you think is the correct answer to the question. Please select one response only.	
Item #	Objectively measured competencies
b.	Accessibility
c.	Accountability
d.	Adequacy
	Total
OA.06	**Which of the following is a characteristic of a health care system based on social justice?**
a.	Access to medical care is viewed as an economic reward of personal effort and achievement.
b.	Production and distribution of health care are determined by market-based demand.
c.	An individual's ability to pay is considered inconsequential for receiving medical care.*
d.	Markets are assumed to be more efficient than government at allocating health resources equitably.
	Total
OA.07	A multi-district coalition is in place to identify successful district-level strategies for enhancing health care and other community services for children with malnutrition. The coalition membership currently includes health care professionals and representatives from the directorates of Health and Family Welfare, Medical Health, Women and Child Welfare, and the Basic Education Department, and seeks broader community engagement. There is one remaining open seat. Which of the following representatives is most appropriate to fill the open slot?
a.	a principal from one of the region's elementary schools
b.	a member of a parent advocacy group*
c.	a pediatric cardiologist
d.	pharmacist
	Total
OA.08	**A good leader…**
a.	Engages in problem avoiding
b.	Avoids conflict at all costs
c.	Connects activities to group's mission*
d.	Holds power and authority
	Total
OA.09	**What does compromise in a negotiation entail?**
a.	Projecting influence
b.	Using facts and data to make your case
c.	Going back and forth until you reach a goal
d.	Finding a solution that everyone can agree on*
	Total

Please check the response option that you think is the correct answer to the question. Please select one response only.	
Item #	Objectively measured competencies
OA.10	**Which of the following questions does NOT represent "systems" thinking approach to a problem?**
a.	Who is responsible for the problem?*
b.	What has happened? (or What is happening?)
c.	Why did it happen?
d.	Why does it matter? (or How can we make improvements?)
	Total
OA.11	**How would you classify the following statement?** **We can't do anything without support from the top.**
a.	Data or Fact
b.	Meaning We've Drawn
c.	Conclusion We've Reached*
	Total
OA.12	**How would you classify the following statement?** **Our budget was cut by 10% this year.**
a.	Data or Fact*
b.	Meaning We've Drawn
c.	Conclusion We've Reached

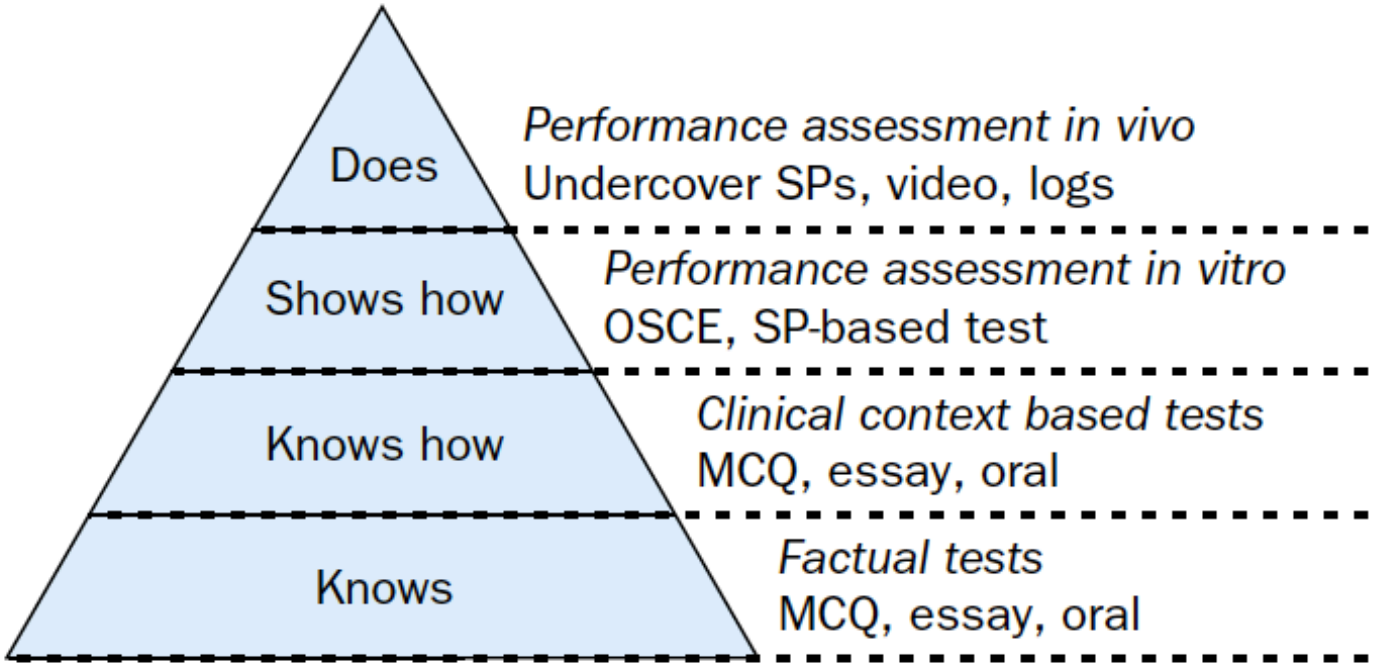
* represents the correct answer for each question

Appendix 21. Bloom's taxonomy



Source: Figure developed by (Vanderbilt University Center for Teaching, 2010), based on (Bloom, 1965).

Appendix 22. Miller's triangle of competency assessment



Adapted from (Miller, 1990; Wass, Vleuten, et al., 2001).
SP=simulated patients; OSCE=objective structured clinical examination; MCQ=multiple-choice questions

Appendix 23. Self-assessment competency assessment tool

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4: 1 = None; I am unaware or have very little knowledge of the skill 2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill 3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill 4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others Note: The statements should be interpreted as broadly as possible to apply to your position and main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.	
Item number	**Survey item**
CA.01	Describe key concepts in public health (e.g., the health status of populations, the determinants of health and illness, strategies for health promotion, relationship between health and poverty, inequities in health and various forms of disadvantages, disease and injury prevention and health protection, as well as the factors that influence the delivery and use of health services.)
CA.02	Apply the public health tools, techniques, and sciences (e.g., behavioral and social sciences, biostatistics, economics, epidemiology, environmental public health, demography) to practice (e.g., community needs assessment).
CA.03	Use data, evidence, and research to inform health policies, programs, and organizational performance.
CA.04	Identify relevant and appropriate sources of information, including community resources.
CA.05	Collect, store, retrieve and use accurate and appropriate data on public health issues.
CA.06	Analyze information to determine appropriate implications, uses, gaps, and limitations.
CA.07	Assess the accuracy and importance of data for public health decision making.
CA.08	Describe selected policy and program options to address a specific public health issue.

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
CA.09	Describe the implications of each policy and program option, especially as they apply to the determinants of health and recommend or decide on a course of action.
CA.10	Develop a plan to implement a course of action taking into account relevant evidence, emergency planning procedures, regulations and policies, and legislation (e.g., government order).
CA.11	Implement a policy, program, or effective practice guidelines (e.g., immunization guidelines, screening programs for illnesses) to address a specific public health issue.
CA.12	Monitor and evaluate an action, policy, or program.
CA.13	Demonstrate the ability to fulfill functional roles in response to a public health emergency.
CA.14	Establish teams for the purpose of achieving program and organizational goals (e.g., considering the value of different disciplines, sectors, skills, experiences, and perspectives; determining scope of work and timeline).
CA.15	Motivate and supervise personnel for the purpose of achieving program and organizational goals (e.g., participating in teams, encouraging sharing of ideas, respecting different points of view).
CA.16	Support learning within an organization including on the job training to advance public health goals.
CA.17	Manage time appropriately.

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
CA.18	Justify programs for inclusion in budgets, develop and defend budgets.
CA.19	Prepare proposals for funding (e.g., foundations, government agencies, corporations).
CA.20	Make use of financial analysis and accounting techniques in making decisions about policies, programs, and services.
CA.21	Manage programs within current and projected budgets and staffing levels (e.g., sustaining a program when funding and staff are cut, recruiting and retaining staff).
CA.22	Identify and collaborate with partners in addressing public health issues.
CA.23	Use skills such as team building, negotiation, conflict management, group facilitation, and mediation between differing interests to build partnerships.
CA.24	Mobilize communities by using appropriate media, community resources, and social marketing techniques.
CA.25	Recognize how the determinants of health (biological, social, cultural, economic and physical) influence the health and well-being of specific population groups.
CA.26	Address population diversity when planning, implementing, adapting, and evaluating public health programs and policies.

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
CA.27	Apply culturally-relevant and appropriate approaches with people from diverse castes, religions, socioeconomic and educational backgrounds, and persons of all ages, genders, health status, sexual orientations and abilities.
CA.28	Listen, engage, and communicate effectively (e.g., by leveraging technology) with individuals, families, groups, communities, and colleagues including supervisors and team members.
CA.29	Interpret information for professional, nonprofessional and community audiences.
CA.30	Advocate and network for healthy public policies and services that promote and protect the health and well-being of individuals and communities.
CA.31	Describe the mission and priorities of the public health organization where one works, and apply them in practice.
CA.32	Contribute to developing key values and a shared vision in planning and implementing public health programs and policies in the community.
CA.33	Utilize public health ethics to manage self, others, information, and resources.
CA.34	Contribute to maintaining organizational performance standards.
CA.35	Build community capacity by sharing knowledge, tools, expertise, and experience.
CA.36	Identify a need for change, manage change and processes.

For each statement, think about the level at which you are currently able to perform the skill. Then rate your level of proficiency on each statement by selecting a number between 1 and 4:

1 = None; I am unaware or have very little knowledge of the skill
2 = Aware; I have heard of, but have limited knowledge or ability to apply the skill
3 = Knowledgeable; I am comfortable with my knowledge or ability to apply the skill
4 = Proficient; I am very comfortable, am an expert, or could teach this skill to others

Note: The statements should be interpreted as broadly as possible to apply to your position and main setting of your work. In the example below, you would select number "4" for "Proficient" if you think you are excelling at this skill or select "1" for "None" if you feel you need a great deal of improvement.

Item number	**Survey item**
CA.37	Maintain organizational justice, equality, and fairness in dealing with subordinates.

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Curriculum Vitae

Sudip Bhandari, MSc, PhD Candidate

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EDUCATION & FELLOWSHIP

Sep 2016 – Present	**Doctor of Philosophy (PhD)** **Johns Hopkins Bloomberg School of Public Health**, Baltimore, Maryland Program: Health Systems, Department of International Health Certificates: Public Health Economics; Evaluation-International Health Programs Advisor: David Peters, MD, DrPH Dissertation: Identification, Tool Development and Validation, and Assessment of Core Competencies of Public Health Professionals in Uttar Pradesh, India
Sep 2015 – Aug 2016	**Master of Science (MSc)** **University of Amsterdam**, Amsterdam, The Netherlands Program: Conflict Resolution and Governance, Department of Political Science Funding: Rotary Foundation Global Grant Scholarship Thesis**:** Health Service Delivery and State Legitimacy in Nepal's Madhesh
June 2014 – July 2015	**Global Health Corps Fellowship** **Harvard University**, Cambridge, Massachusetts Program: Global Health Delivery Project Selected as one of 128 fellows from 6000 applicants
Sep 2010 – May 2014	**Bachelor of Arts (BA)** **Saint Olaf College**, Northfield, Minnesota Program: Public Health Study Abroad: American University in Cairo (Egypt); Chinese University in Hong Kong (Hong Kong); Ecumenical Christian Center (India); Yonsei University (South Korea)

PROFESSIONAL & RESEARCH EXPERIENCES

March 2018 – Current	**Research Assistant, Uttar Pradesh Health Systems Strengthening Support** **Johns Hopkins Bloomberg School of Public Health** Scope of work: Support data collection activities in the state of Uttar Pradesh, India. Develop Request for Proposal (RFP) to hire data collection agencies, coordinate with government bodies and Institutional Review Boards (IRBs) for ethical approvals, train and supervise enumerators, conduct data analysis, and present findings. Provide technical and analytical support to the state government.
Dec 2017 – March 2020	**Consultant, Global Practice of Health, Nutrition, and Population** **The World Bank**, Washington DC Scope of work: Primary Health Care Performance Initiative (PHCPI) project: Completed identification, analysis, and documentation of critical national-level quantitative primary health indicators using the health facility survey in Papua New Guinea (PNG).

Integrating Externally Financed Health Programs project: Analyzed Papua New Guinea's financing and service delivery trends, with a particular focus on immunization, HIV, malaria, and TB programs. Developed policy briefs, concept notes, abstracts, and presentations for research and press conferences.

May 2018 – Aug 2018 **Graduate Intern, Global Health Division**
Bill and Melinda Gates Foundation, Seattle, Washington
Scope of work: Conducted scoping review to analyze the evidence base that supports the change of routine immunization schedule for children below one year of age globally. Developed research posters and pre-reading material for the convening of subject matter experts in London, UK, to discuss the latest immunological and delivery research. Supported the development of a strategy to fund research projects that address unanswered immunological and delivery questions for a schedule change.

Sep 2017 – Dec 2017 **Research Assistant, Future Health Systems Liberia**
Johns Hopkins Bloomberg School of Public Health
Scope of work: Conducted a literature review to identify gaps in knowledge about health systems resilience in Liberia. Analyzed secondary data using Stata. Wrote IRB proposal for primary data collection in Monrovia, Liberia. Developed interview guides for key-informant interviews with stakeholders. Wrote manuscripts for peer-reviewed publications highlighting notable findings from the project.

June 2017 – Aug 2017 **Research Assistant, Behavior Surveillance Research Study**
Johns Hopkins Bloomberg School of Public Health
Scope of work: Conducted cleaning and coding of datasets that included individual-level data from surveys of Injection Drug Users (IDUs) and Men who have Sex with Men (MSM) in Baltimore. Developed statistical models to understand trends in the socio-economic status of these groups. Wrote manuscripts for peer-reviewed publications.

Jan 2017 – June 2017 **Research Assistant, Center for Public Health and Human Rights**
Johns Hopkins Bloomberg School of Public Health
Scope of work: Led data management, validation, and cleaning process for a monitoring and evaluation (M&E) study of HIV-related interventions in Baltimore City, Maryland, and Jackson, Mississippi. Performed weekly data quality checks, prepared weekly data management reports, including the summary of data quality concerns, wrote and ran cleaning code to address data quality concerns based on information gathered at data validation meetings with grantees. Produced tables and graphs using survey data for quarterly project reports.

Sep 2016 – Jan 2017 **Student Investigator**, **International Vaccine Access Center**
Johns Hopkins Bloomberg School of Public Health
Scope of work: Reviewed published and unpublished literature from around the world about the efficacy of Pneumococcal Conjugate Vaccine (PCV). Abstracted data from the selected literature through an online platform, DistillerSR, for meta-analyses. Supported the process of writing reports to be shared with policymakers in the World Health Organization in Geneva, Switzerland.

June 2014 – July 2015 **Global Health Corps Fellow, Global Health Delivery Project**
Harvard University, Cambridge, Massachusetts
Scope of work: Managed an international grant subscription program of a clinical resource database, UpToDate. Coordinated research to evaluate the program's impacts and published findings in a research journal. Identified and developed plans to expand the institute's research portfolio in four African countries. Provided communications support to disseminate research conducted by the institute globally. Led literature reviews around myriad public health issues, including mental health programs in low-resource settings and the role of community-based organizations in improving insurance coverage in the United States. Organized week-long panels by inviting experts to share knowledge and discuss challenges on these topics. Coordinated to write and publish peer-reviewed synopses of the panels by summarizing challenges, innovative approaches, and best practices.

June 2013 – Aug 2013 **Undergraduate Research Scholar**
University of Minnesota, Minneapolis, Minnesota
Scope of work: Conducted quantitative research about mental health characteristics of Minnesota students who carry guns. Completed an extensive literature review to identify gaps in the literature about firearm violence prevention. Applied for the IRB review and followed necessary reporting procedures. Coordinated with Minnesota's Department of Education and Department of Health to acquire the dataset. Collaborated with a team of researchers to analyze the data using SPSS. Presented the research in local as well as national conferences and developed a manuscript for publication.

PEER-REVIEWED PUBLICATIONS

[1] **Bhandari S**, Alonge O. Measuring resilience of health systems in low- and middle-income countries: a focus on community resilience. Health Research Policy and Systems 2020.

[2] Gupta M, Wahl B, Erchick D, Adhikari B, Coria A, **Bhandari S**, et al. Need for COVID-19 research in low- and middle-income countries. Global Health Research and Policy 2020.

[3] **Bhandari S**, Wahl B, Bennett S, Engineer C, Pandey P, Peters D. Identifying core competencies for public health professionals: results from a Delphi exercise in a low-income setting. BMC Public Health [Under Review] 2020.

[4] **Bhandari S**. Health Service Delivery and State Legitimacy in Nepal. Public Administration and Development [Under Review] 2020.

[5] Valtis YK, Rosenberg J, **Bhandari S**, Wachter K, Teichman M, Beauvais S, et al. Evidence-based medicine for all: what we can learn from a programme providing free access to an online clinical resource to health workers in resource-limited settings. BMJ Global Health 2016.

[6] **Bhandari S**, Thul C, Johnson K, Borowsky I. Emotional and behavioral health characteristics of adolescents who carry guns to school. Proceedings of The National Conference on Undergraduate Research 2014.

RESEARCH PRESENTATIONS

[1] **Bhandari S**. 6Ms Framework for Dissertation Determination: Supporting Global Health Doctoral Students to Choose the Right Dissertation Project. [Poster Accepted] at the: 11th Annual Consortium of Universities for Global Health Conference [Conference Cancelled]; 2020; Washington, D.C.

[2] **Bhandari S**. Health Service Delivery and State Legitimacy in Nepal's Madhesh. [Poster Accepted] at the: 5th Global Symposium on Health Systems Research; 2018; London, United Kingdom.

[3] Rosemberg N, **Bhandari S**, Arur A. Implications of Facility Service Delivery Readiness for Patient Satisfaction. [Poster Accepted] at the: Pacific Update Conference; 2018; Suva, Fiji.

[4] Valtis YK, **Bhandari S**. Expanding Access to Evidence-based Medicine to Physicians and Medical Students in Resource-poor Settings to Improve Medical Education. [Poster Accepted] at the: 7th Annual Consortium of Universities for Global Health Conference; 2016; San Francisco, California.

[5] **Bhandari S**. UpToDate-GHDonline collaboration: Increasing uptake and access. Poster presented at the: 6th Annual Consortium of Universities for Global Health Conference; 2015; Boston, Massachusetts.

[6] **Bhandari S**. Emotional and behavioral health characteristics of adolescents who carry guns to school. Oral presentation presented at the: National Conference on Undergraduate Research; 2014; Knoxville, Kentucky.

[7] **Bhandari S,** Shrestha P, Bastola S. Medical potential of Cordyceps sinensis of Nepal. Oral and poster presentations presented at the: 4th International Students Science Fair; 2008; Kyoto, Japan.

TEACHING EXPERIENCE

2018 Teaching Assistant, Applying Summary Measures of Population Health to Improve Health Systems
Johns Hopkins Bloomberg School of Public Health

2017 Teaching Assistant, Quality Assurance Management Methods for Developing Countries
Johns Hopkins Bloomberg School of Public Health

2016 Teaching Assistant, Social and Behavioral Foundations of Primary Health Care
Johns Hopkins Bloomberg School of Public Health

PROFESSIONAL PARTICIPATION

2020 Landscape Symposium
Global Health Council, Washington DC

2018 Convening on the Change of Routine Immunization Schedule
Bill and Melinda Gates Foundation, London, United Kingdom

2018 Annual Universal Health Coverage Financing Forum
The World Bank Group and USAID, Washington DC

2017 Landscape Symposium
Global Health Council, Washington DC

2017 Stata Conference
StataCorp LLC, Baltimore, Maryland

2016 International Conference on Migration Crisis in Europe
Humanity in Action, Athens, Greece

2015 Training Workshop on Effective Communication and Mediation
Humanity in Action, Berlin, Germany

2015 Global Health and Innovation Conference
Unite for Sight, New Haven, Connecticut

2014 International Conference on Border Disputes
Humanity in Action, Sønderborg, Denmark

2014 Global Health Corps Training Institute on Leadership
Yale University, New Haven, Connecticut

2014 Clinton Global Initiative University Conference on Entrepreneurship
Arizona State University, Tempe, Arizona

2012 Clinton Global Initiative University Conference on Entrepreneurship
George Washington University, Washington DC

HONORS, AWARDS, & RECOGNITIONS

2020 Speaker scholarship, Sixth Global Symposium on Health Systems Research
Health Systems Global
Received complimentary registration and membership in the organization for two years

2020 JB Grant Society Annual Global Health Photography Competition, Center for Global Health
Johns Hopkins Bloomberg School of Public Health
Won 1st place for a photo highlighting inequality in India

2019 Eckert-Fazen Endowment for Human Resources for Health in Low- and Middle-Income Countries
Johns Hopkins Bloomberg School of Public Health
Received $1,850 to support research on public health competency assessment in Uttar Pradesh, India

2017 Health Systems Award
Johns Hopkins Bloomberg School of Public Health
Secured $1,500 for a short-term research project to evaluate health delivery in post-earthquake Nepal

2017 Richard Morrow Scholarship
Johns Hopkins Bloomberg School of Public Health
Received $3,000 as recognition of commitment to creating new or better pathways to improve health among the world's underserved populations

2016 Doctoral Award
Johns Hopkins Bloomberg School of Public Health
Received over $160,000 as a scholarship to fund the doctoral studies

2015 Senior Fellow Award
Humanity in Action, New York, NY
Attained $4,400 Senior Fellow Grant to co-found Anne Frank Project Poznan in Poland

2014 Jacobson Scholarship
Vincent L. Hawkinson Foundation for Peace and Justice, Twin Cities, Minnesota
Received $5,000 as seed funds to establish the Anne Frank School of Nepal

2014 Commencement Student Speaker
St. Olaf College
Delivered a speech to professors, parents and the graduating class about my life journey

2014 Rotary Global Grant Scholarship
Rotary International Foundation
Awarded $30,000 to pursue a master's degree at the University of Amsterdam

2014 Distinguished Senior Leadership Award
St. Olaf College
Recognized as the student of the year for outstanding contribution to the student's civic body

2014 Presidents' Student Leadership Award
Minnesota Campus Compact, Minneapolis, MN
Awarded for a deep commitment to civic responsibility and leadership to address public issues

2013 Undergraduate Poster Session Travel Award
University of Minnesota
Attained $1,500 for developing one of two best posters among undergraduate researchers

2013 Established Leader of the Year
St. Olaf College
Awarded as one of two students for demonstrating the commitment to campus leadership roles

2013 Entrepreneurial Grant
St. Olaf College
Attained $3,000 to start Ole Thrift Shop, a business to recycle waste generated by student residential life

2012 Outstanding Educator of the Year
Anne Frank Center, New York, NY
Awarded $1,000 for founding Anne Frank Project Nepal; the first undergraduate student to be honored

2012 Davis Scholarship
Davis Projects for Peace, Vermont, NH
Received $10,000 to scale up Anne Frank Project Nepal

2012 Entrepreneurial Grant
St. Olaf College
Attained $3,000 to start STO Talks, a TED Talks inspired event

2012 Entrepreneurial Grant
St. Olaf College
Received $3,000 to start Anne Frank Project Nepal

2010 Service and Leadership Scholarship
St. Olaf College
Awarded annually starting 2010 till 2014 for active participation in local community service

2010 International Student Scholarship
St. Olaf College
Attained $200,000 to cover all expenses during the undergraduate degree

LEADERSHIP EXPERIENCES

June 2011 – Present — **Founder and Director**
Anne Frank Project Nepal, Nepal
Scope of work: Developed a human rights and Holocaust education program in Nepal over the summer of 2011. Planned, directed, and implemented traveling photo exhibitions and seminars teaching middle and high school students about the Holocaust, the Second World War, and Anne Frank. Reached 2,300 students in five districts. Expanded the project in 2012. Reached 2,700 new students across Nepal and founded a peace library for 250 war-affected students in a rural village. Collected student pledges and successfully appealed to the Nepali Ministry of Education to revise the national school curriculum to include topics on human rights. Collaborated with the national government officials to amend the high school curriculum. Currently establishing Anne Frank School of Nepal, the first of its kind in Asia. Coordinate with stakeholders and apply for grants in the USA, Germany, and Netherlands to finance project activities.

Sep 2015 – Aug 2016 — **Co-Founder and Co-Director**
Anne Frank Project Poznan, Poland
Scope of work: Initiated and oversaw a summer school to teach high school students about the history of Polish Jews. Supervised the planning, directing, and implementing human rights advocacy seminars for the students. Developed and presented reports to donors on the organization's reach and impact.

COMPUTING & LANGUAGE SKILLS

- Proficient in applications of Stata for data analysis, programming, and data visualization
- Working knowledge of R, SPSS, and Python
- Experienced in survey platforms: Survey CTO, SurveyMonkey, Typeform, Magpi
- Skilled in using reference managers (EndNote, Mendeley, Zotero), project management (Asana)
- Proficient in MS Office applications
- Language: English (advanced), Nepali (native), Hindi (advanced), Urdu (advanced-spoken)

COUNTRIES VISITED (ACADEMICALLY & PROFESSIONALLY)

Austria, Belgium, Denmark, Egypt, France, Germany, Greece, Hong Kong, Hungary, India, Italy, Japan, Kenya, Malaysia, Maldives, Nepal, Netherlands, Poland, Portugal, Rwanda, South Korea, Singapore, Spain, Sweden, Switzerland, Tanzania, Thailand, Turkey, United States of America, United Kingdom